REPORT
OF
GUN FOUNDRY BOARD

1884

Hemsley's

Rec'd April 15/84

REPORT

OF THE

GUN FOUNDRY BOARD

ORGANIZED BY

THE PRESIDENT

IN ACCORDANCE WITH

ACT OF CONGRESS APPROVED MARCH 3, 1883.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

CONTENTS.

APPENDICES.

REPORT OF GUN FOUNDRY BOARD.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING

A report of the Board of Army and Navy Officers relative to the best location for establishing a Government foundry.

FEBRUARY 20, 1884.—Referred to the Committee on Appropriations and ordered to be printed.

To the Senate and House of Representatives:

I transmit herewith to the House of Representatives the report of a Board of Army and Navy Officers, appointed by me in accordance with the act of Congress approved March 3, 1883—

For the purpose of examining and reporting to Congress which of the navy-yards or arsenals owned by the Government has the best location and is best adapted for the establishment of a Government foundry, or what other method, if any, should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States; the cost of all buildings, tools, and implements necessary to be used in the manufacture thereof, including the cost of a steam-hammer or apparatus of sufficient size for the manufacture of the heaviest guns.

CHESTER A. ARTHUR.

EXECUTIVE MANSION,
February 18, 1884.

GUN FOUNDRY BOARD,
1727 *Pine Street, Philadelphia, Pa., February* 16, 1884.

To the President:

In accordance with your instructions of April 2, 1883, issued under the provision of section 1 of the "Act making appropriations for the naval service for the fiscal year ending June 30, 1884, and for other purposes," approved March 3, 1883, the Board, composed of six officers selected from the Army and Navy, "for the purpose of examining and reporting to Congress which of the navy-yards or arsenals owned by the Government has the best location and is best adapted for the establishment of a Government foundry, or what other method, if any, should be adopted for the manufacture of heavy ordnance adapted to

modern warfare, for the use of the Army and Navy of the United States; the cost of all buildings, tools, and implements necessary to be used in the manufacture thereof, including the cost of a steam-hammer or apparatus of sufficient size for the manufacture of the heaviest guns," has the honor to submit herewith its report and the record of its proceedings.

In order to reply satisfactorily to the act of Congress, it was necessary for the Board to seek information in Europe, and visits were made to England, France, and Russia. It is appropriate to state that your Board was received by both Government officials and by private companies with much cordiality, and every assistance was rendered in its investigations in those countries.

It was the desire of the Board also to visit the large German steel works at Essen, but the permission to do so, which was requested of Mr. Fried. Krupp, was not granted for reasons that will be found stated in the copy of correspondence attached to this report.

The Board, having completed its duties, has adjourned *sine die*.

Very respectfully, for the Board,

E. SIMPSON,

Rear-Admiral, United States Navy, President of the Board.

REPORT

OF THE

GUN FOUNDRY BOARD.

The act of Congress, approved March 3, 1883, under which the Gun Foundry Board was organized, calls for a report on the following points:

1st. Which of the navy-yards or arsenals owned by the Government has the best location, and is best adapted for the establishment of a Government foundry.

2d. What other method, if any, should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States.

3d. The cost of all buildings, tools, and implements necessary to be used in the manufacture thereof, including the cost of a steam-hammer or apparatus of sufficient size for the manufacture of the heaviest guns.

The first question presupposes the establishment of a Government Gun Foundry, properly so called, the establishment to be under the absolute control of the Government, and the details of all work to be supervised and directed by Government officers.

The answer to this question involves simply an expression of opinion as to the superior adaptability, for the purposes of a gun foundry, of any navy-yard or arsenal now owned by the Government.

The second question imposes no limitation, and calls upon the Board to suggest "any other method" (apart from a Government foundry, pure and simple) by which the purposes of the act of Congress can be achieved. The Board is evidently called upon to consider the subject of joint action between the Government and private parties for the accomplishment of a national purpose.

The Board decided that there were three points of view from which this subject should be considered, viz:

1st. That the Government should supplement the plants of some of the steel workers of the country with such additional tools and implements as would enable them to turn out finished steel cannon.

2d. That the Government should give contracts of sufficient magnitude to enable the steel workers of the country to supply the finished guns without its direct aid.

3d. That the Government should establish on its own territory a plant for the fabrication of cannon, and should contract with private parties to such amounts as would enable them to supply from the private industries of the country the forged and tempered material.

The course of the investigation being thus indicated, the Board addressed circular letters to several of the steel manufacturers in the country and to the two companies employed in the fabrication of cannon. These letters and the replies thereto will be found in the correspondence attached to the record of proceedings of the Board, and copies are appended to this report. The replies were unsatisfactory, the subject being a new one to the parties addressed. The expense to be incurred could not be calculated upon any known basis, and the

Board was unable to satisfy the calls made upon it for further information as to the number of guns required or the probable extent and cost of a plant for the manufacture of such heavy guns as the act of Congress contemplated.

It was evident that none of the desired information could be obtained from our manufacturers, because of their lack of experience on this subject. It was known, too, that several of the European Governments had had more or less experience of joint action with private artillery establishments. The call by the act of Congress for "the cost of all buildings, tools and implements for the manufacture of the heaviest guns" could only be answered by information and experience obtained from abroad, as no such tools or implements have been manufactured or are in use in the United States. The steam-hammer mentioned in the act was recognized as a subject requiring careful consideration. It is coupled with a qualification, "or apparatus of sufficient size," which indicates that there existed a doubt as to the propriety of the use of a steam-hammer for forging if other "apparatus of sufficient size" could be made more efficient. The advances made of late years in the process of forging by compression made this a very important matter for consideration. This subject is necessarily connected with that of the manufacture of the metal to be forged, and involves a study of the recent developments in steel. The actual condition of the armaments abroad, so far as it illustrates the latest ideas, was felt by the Board to be an important part of the information on which it should report, as the character of the new constructions of cannon would necessarily control that of the tools to be recommended for use in their fabrication.

The foregoing reasons governed the Board in its decision to represent the necessity of seeking information abroad. Orders were issued and the Board proceeded to Europe. The first visit was made to England.

ENGLAND.

SOURCES FROM WHICH THE ARMAMENT OF ENGLAND IS SUPPLIED.

Previous to the year 1859 the Royal Arsenal of Woolwich was the only source from which the armament of England was supplied. The arsenal was a purely governmental establishment, in which there were several departments. The department of the Royal Gun Factories was always under the command of an officer of the Royal Artillery; and here all cannon for the army and navy were fabricated.

Since the year 1859, the Elswick Works at Newcastle-on-Tyne has been a source of supply on which the Government has drawn more or less for guns. The experience of the connection of the English Government with these private works bears directly upon the subject of joint action between a Government and a private firm.

This connection dates from the time when attention was called to the improvements in rifled ordnance inaugurated by Mr. William G. Armstrong.

The Armstrong gun was first brought to the notice of the Government in 1854, and in July, 1855, a 3-pounder was delivered, with a report of the experiments that had been made with it. The gun was re-bored up to a 5-pounder, and in December, 1856 was tried; the report stated that good practice was obtained at 1,500 and 2,000 yards. In January, 1857 a second gun was ordered. It was an 18-pounder, and was tried in January, 1858. The report was favorable, and the gun was so far

approved as to cause the recommendation that two should be issued to the artillery to "knock-about, and be reported on as to their endurance of work in comparison with the service guns."

In 1858 there arose a pressure for a supply of rifled field guns for the army, and a committee, after investigation, reported that it was expedient to experiment only with the Armstrong and Whitworth guns.

There has always been a controversy as to the manner in which the comparison between these two guns was made. But the result of the trial was the adoption of the Armstrong system for field service, which at this time involved the following combination of construction, viz: breech-loading, rifling, and coating the projectile with soft metal.

In order to obtain as soon as possible a supply of these guns, it was decided to supplement the resources of Woolwich by entering into arrangements with a company set up at Elswick for the manufacture of the guns and projectiles. A guarantee was given to this company on the 16th of January, 1859, to secure them against loss by the erection of buildings and machinery. The Government undertook to keep them in full work, but reserved the right to terminate the engagement on the payment of compensation. The necessities of the service requiring a larger number of these guns to be provided than was at first anticipated, the original guarantee was increased, first to £50,000, and then to £60,000. In October, 1859, owing to increased pressure for guns, the guarantee was raised to its final amount of £85,000.

Sir William Armstrong was, on the 22d of February, 1859, appointed engineer of rifled ordnance, and on the 4th of November, 1859, he became also the superintendent of the Royal Gun Factories, which office he held until February, 1862. This was the first time that office had been filled by a civilian.

In September, 1859, the 40-pounder Armstrong gun was approved for the navy. Proposals were also approved for the construction of a 110-pounder gun, and one hundred of these guns were constructed before any experiments with them had been concluded.

The Government was thoroughly committed to the Armstrong system, and the manufacture was carried out at Woolwich by the Government, and at Elswick by a private company.

The large expenditures having attracted attention, a committee was appointed in 1862 to inquire into them, and in April, 1863, the agreement with the Elswick Company was terminated by the Government, which discontinued all orders to it and concentrated its work at Woolwich. The guarantee of £85,000 was paid, the Government, however, being credited with the value of plant and stores, estimated at £19,000, making the amount in money paid £65,534 4*s*.

The committee reported that during the continuance of the agreement with the Elswick Company the following sums had been paid:

(1.) The sum of £965,117 9*s*. 7*d*. for articles supplied.

(2.) After giving credit for the value of plant and stores received from the company, a sum of £65,534 4*s*., as compensation for terminating the contract.

(3.) The outstanding liabilities of the War Office to the Elswick Ordnance Company, for articles ordered, amounted on the 7th of May, 1862, to the sum of £37,143 2*s*. 10*d*.

The whole of these payments and liabilities amounts to the sum of £1,067,794 16*s*. 5*d*.

During the same period there had been expended in the three manufacturing departments at Woolwich on the Armstrong guns, ammuni-

tion and carriages, the sum of £1,471,753 1*s.* 3*d.*, making altogether a grand total of £2,539,547 17*s.* 8*d.*

A statement prepared by one of the assistant accountants-general of the War Office shows the cost of certain guns and projectiles obtained from the Elswick Ordnance Company compared with the rates of those produced at the Royal Arsenal at Woolwich. According to this statement, taking the class of stores which have been supplied from Elswick and from Woolwich, and which therefore admit of a direct comparison, the sum of £242,173 10*s.* 6*d.*, on an expenditure of £593,275 10*s.* 11*d.*, would have been saved to the public had these guns, projectiles and fuzes, supplied by the Elswick Ordnance Company, been manufactured in the Royal Arsenal.

The evidence on this subject is acknowledged to be somewhat conflicting. Colonel Boxer, who was the superintendent of the Royal Laboratory at Woolwich, and the accountant-general of the War Office state their belief that the statement is substantially correct, while Mr. Rendel and Captain Noble, R. A., partners in the Elswick Company, object to the basis on which the prices at the Royal Arsenal were ascertained; but there seems no doubt a saving would have been effected if all the articles had been manufactured at the Royal Arsenal.

The above is a statement of facts which exhibits the experience of the English Government in its experiment of joint action with a private company. The plant put up by the Government became the property of the private company at a nominal valuation, and the Government paid about £65,000 to break the agreement, besides paying an increased price on articles manufactured for it.

Elswick.—The subsequent history of the Elswick Ordnance Company under the control of Sir William Armstrong is well known. The plant for the manufacture of cannon has been kept employed by orders from foreign Governments, and during late years much work has been done for the English Government. The enterprise and ability in its management has been of great assistance to the country, and, at the recent readoption of the breech-loading system, the Government found Elswick prepared to assist in advancing the manufacture.

Thus, though there seems to have been no profit to the Government in working jointly with the Elswick Company, much aid has been derived from it as an independent assistant, and it may be said that it is the only one which supplements the royal factories in finishing guns.

The establishment at Elswick is thoroughly equipped for heavy work and has produced the largest guns in the world. The shops are supplied with an abundance of fine tools, and the forge arrangements have been, up to the present time, all that was required for the manufacture of the guns heretofore turned out. But a change is being made in some of the details to better accord with the demand for steel cannon, and steel works are being erected capable of casting 100-ton ingots. Blast furnaces are also in operation.

The fact that the Government has abandoned the wrought-iron gun impairs the usefulness of the broad tup-hammer with which the wrought-iron coils were welded, and this is being modified to be more effective for forging steel ingots and hoops. The advantages of the Whitworth manufacture are also recognized and a forging press is being introduced.

The use made of hydraulic power is probably greater at Elswick than at any other establishment in the world. This might naturally be expected, when it is borne in mind that the world is indebted to Sir William Armstrong for the advance made in this direction.

The system of hydraulics at Elswick extends to all parts of the grounds, reaching all the shops, wharves, and water front. Pumping-engines are established at convenient intervals, only one working at a time, and the connection of pipes being continuous, the uniform working of the system is established by five or six accumulators with 18-inch rams. The working of the pumping-engine is made automatic. The accumulator nearest to it is slightly more heavily loaded than the others to give a lead in rising to the distant one, and is connected with a steam regulating valve to act as a governor for adjusting the speed of the engine to the varying demand of the hydraulic machines. The pressure sustained throughout the system is 750 pounds to the square inch. The pipes are usually 5 inches in diameter, the largest being 6 inches.

Hydraulic power is used for the forge and foundry cranes, also for the movable cranes which operate along the water-front. For the accommodation of these last, pipes are run, in junction with the pressure main, with hydrants from 18 to 36 feet apart, from which connection is made with the cranes by means of telescopic tubes. Two or more cranes can thus be brought into operation on any vessel at the water-front.

On the east end of the wharf are erected large hydraulic shears, worked by a direct-acting hydraulic cylinder, 40-feet stroke, lifting 120 tons. The back leg moves so as to bring the lifting cylinder about 30 feet out; the foot is moved by a screw 50 feet long, with hydraulic engine and gear.

The most notable hydraulic crane that has been produced from these works is the one erected in the Italian naval arsenal at Spezzia, which is capable of lifting 160 tons through a range of 40 feet. It is carried upon a ring of line rollers supported by a pedestal of masonry, and the slewing is effected by an hydraulic engine applied to a pinion which gears with a circular rack. The rake of the jib or projection from the center of rotation is 65 feet, and its height from the quay-level is 105 feet. The crane is counterbalanced on the side opposite to the load.

About the grounds at Elswick, particularly at the approaches to the shops, there are numerous small capstans worked by hydraulic engines, which are of great service in hauling heavy loads into or out of shops, and in transporting them from shop to shop.

It is almost unnecessary to add that it is at Elswick that the applications for working heavy guns by hydraulic power have been designed and manufactured.

No foundry or gun factory can be considered efficiently equipped without being provided with arrangements for the plentiful supply of hydraulic power.

Woolwich.—The Royal Gun Factories at Woolwich are of very extensive proportions, and have, in the course of many years, become so well equipped that the present change which has been inaugurated in the system of manufacture of the English gun does not find it unprepared. In a Parliamentary report of 1878–'79 a balance sheet states the value of all the property and material in the three departments at Woolwich, as follows, viz:

	£	s.	d.
Land	2,805	9	4
Buildings	97,684	7	11
Machinery	166,110	11	3½
To one year's interest, at 3½ per cent. on invested capital, viz: stores and semi-manufactured articles in stock, April 1, 1878	196,949	15	3
Total	463,550	3	9½

The capacity for production in the gun factory is stated in 1873–'74 to have been 6,000 tons of guns of various calibers per year, or 7,500 tons of rough forgings (wrought iron).

An approximation to the number of tools may be reached by citing the number of boring-machines now in place, viz:

2 of 72 inches swing, 4 of 51 inches swing, 4 of 42 inches swing,
4 of 36 inches swing, 6 of 30 inches swing, 6 of 24 inches swing,
12 of 20 inches swing,

besides 50 or 60 others of various smaller sizes.

Of other machines there are—

6 planing-machines, 12 shaping-machines, 12 milling-machines,
12 drilling-machines, 12 slotting-machines, 6 radial-machines,
2 dividing- machines,

Of traveling cranes there are—

4 of 60 tons capacity, 6 of 30 tons capacity, 6 of 25 tons capacity,

besides several of from 20 to 9 tons capacity.

The steam-hammers are comprised in the following list:

1 of 40 tons, 1 of 12 tons, 1 of 10 tons, 2 of 7 tons, 2 of 6 tons,

besides many of from 3 to 1 ton.

The steam power in the Royal Gun Factories is supplied by 40 boilers of 40 horse-power each. The uniform capacity of boilers is found convenient in case of repairs, when substitutions have to be made. At one point there are assembled 24 boilers in one group.

The new feature about the gun factories at Woolwich is the establishment of a foundry for casting steel. The development of this branch of the manufacture is still in its infancy, but already there are several Price's retort furnaces in operation, having a total capacity of about 18 tons. The tests of the metal have proved to be very satisfactory, and already some tubes have been accepted for the manufacture of 6-inch steel guns. It is expected, in a very short time, that tubes for 8-inch guns will be produced from this foundry.

The 40-ton steam-hammer, which has been used for welding the large coils of wrought iron used in the late manufacture of the Woolwich gun, is undergoing a change, by having the face of the tup reduced in area in order to be made more efficacious in forging steel ingots. Opportunity is also being taken to reconstruct and repair a portion of the foundation and the anvil block in order to suit the new conditions. In this connection it may be well to state the cost of this hammer, including that of the four cranes used in connection with it, furnished by Nasmyth, Wilson & Co.:

Hammer	£4,980
Cranes and framing	13,500
Expended in department	10,915
Inspector of works, charges for building foundations, furnaces, &c	9,245
Floor plates	3,683
	42,323

Steel Manufacturers.—While considering the sources from which the armament of England is supplied, the steel manufacturers who provide the tubes, jackets and hoops should be named. They are:

Thomas Firth & Sons, Sheffield.
Charles Cammell & Co., Sheffield.
Vickers, Sons & Co., Sheffield.
Sir Joseph Whitworth & Co., Manchester.

A foundry for steel casting is now being added to the plant at Elswick.

Heretofore the gun-carriages for both the army and navy have been provided from the gun-carriage department at Woolwich on their own designs; but since the adoption of the Vavasseur gun-carriage by the Admiralty, the works at Elswick, as well as the London Ordnance Works of Mr. Vavasseur, have been called upon to supplement Woolwich in the production of a supply of these carriages. At the present time the Admiralty have on hand, or under construction, about 450 of them suited for all calibers of guns.

CONDITION OF STEEL MANUFACTURE.

The Board visited the following works, viz:
Thomas Firth & Sons, Sheffield.
Sir John Brown & Co., Sheffield.
Charles Cammell & Co., Sheffield.
Vickers, Sons & Co., Sheffield.
Sir Henry Bessemer, Sheffield.
Sir Joseph Whitworth & Co., Manchester.
Bolckow, Vaughan & Co., Eston.

Until within a very few years, the steel for gun metal has been confined in England to that produced from crucibles, and it is only since the general application of the Siemens-Martin Process that Open-Hearth steel has come into competition with it. The uniform results that are now attainable with this process show that the period for the exclusive use of crucible steel for cannon has passed. Some of the steel manufacturers have advanced very far in the use of the open-hearth, and all are making arrangements for embarking in this system of manufacture. This process is much cheaper than that by the crucible, and, its success being established, that reason alone would be sufficient to cause the change in the system; but there are other reasons now operating in England which make the change of manufacture necessary in order that her steel works shall retain their position in commerce and be enabled to answer the calls made on them by the Government.

As long as the demand for steel was confined to orders which required small ingots, the product of the crucibles was sufficient, and the force of laborers required was not excessive; but since the introduction of steel into the process of forming armor-plates, and the corresponding increase in the size of parts requisite for the guns to pierce the new armor, the organization of a force to cast, from crucibles, masses to answer these demands has become a difficult matter. The changes that were commenced a few years ago in some, and which are now being introduced in all the works at Sheffield, are necessary to prevent the purchase from other sources of the masses of steel now required by the Government.

The new departure in the system of gun construction, described farther on in this report, will demand from the Sheffield steel manufacturers increased effort. Up to the present time the only portion in the construction of the Woolwich gun that required steel was the tube; the breech-pieces and hoops, being made of coiled wrought iron, were fabricated at Woolwich. The new construction requires that steel shall be used throughout, and the castings for the jackets for guns now in hand at Woolwich can hardly be supplied from Sheffield. It is well known that the tubes for the 100-ton guns, manufactured at Elswick by Sir

William Armstrong, which required an ingot of 42 tons, had to be made in two pieces because the capacity of Sheffield was not sufficient to make the casting in one, and it is fair to suppose that the use of the *coiled steel* breech-pieces, now used at Woolwich to build up the 43-ton gun, was induced by the difficulty of procuring masses of steel of sufficient magnitude to make proper jackets for them. If this be not the case in regard to the 43-ton guns, the embarrassment is very likely to arise with the 62-ton steel gun now in contemplation. But whether any serious embarrassment has yet arisen or not, owing to the limited capacity of Sheffield for casting gun-metal, it is evident that whatever margin the manufacturers now have, it is very slight, and it behooves them to increase their plant for casting.

The question of *forging* steel ingots is one which is evidently occupying the attention of the steel manufacturers in Sheffield, but on which they are reticent. The important works are all supplied with steam-hammers of greater or less weight, varying from 15 to 25 tons, and each manufacturer claims that his works are thoroughly equipped in this respect for accomplishing the necessary work on an ingot of any size; but it was observed that in one important establishment preparations were being made for the introduction of a large press to take the place of, or to supplement the work of, the hammer. The success of Sir Joseph Whitworth's process of forging by hydraulic compression, and the enviable character acquired by the products of his works in Manchester, have induced the Sheffield manufacturers to take into consideration the probable advantages of the process. As to the advantage or practicability of the compression of steel in the liquid state they are entirely skeptical, but the efficacy of forging under hydraulic compression is conceded, though it is claimed that this must be done under a heat much higher than that required for forging under a hammer, which is considered an objection to the process.

Owing to the character of seclusion that Sir Joseph Whitworth has preserved to his works, the manufacturers of steel at Sheffield have no personal knowledge of the process adopted at Manchester. Their knowledge is limited to meager reports, but the Board was allowed the privilege of carrying on its investigations within the works, where, under orders from Sir Joseph, his representatives exhibited, with explanations, the operations carried on in this unique establishment. It may be distinctly asserted that the experiences enjoyed by the Board during its visit amounted to a revelation.

Whitworth's Works.—Upon its first arrival in London the Board was invited by Sir Joseph Whitworth to examine his works, but with the desire expressed that the visit should be postponed until the close of our foreign investigations. This request was, of course, readily acceded to, and it will be thus seen that previous to the visit to Manchester the members of the Board had received all the impressions that could be produced by viewing the operations at the chief steel factories in France and Russia, and the great factories of Sheffield, in England.

In speaking of the Whitworth establishment at Manchester as unique, and of the process of manufacture at that place as a revelation, reference is specially made to the operation of *forging*. As to the assorting of ores, and the treatment of metal in the furnaces, there is no intention to draw distinctions; but as to the treatment of the metal after casting there can be no doubt of the superiority of the system adopted by Sir Joseph Whitworth over that of all other manufacturers in the world. The process here adopted has been kept singularly exempt from scrutiny. Even in the offices of the chiefs of artillery there can be found no in-

formation, within the knowledge of the Board, which is at all satisfactory upon the subject. Whatever knowledge there is seems to come from hearsay—none from personal observation—and it is only from personal observation that the merits of the system can be fully appreciated.

The system of forging consists in compressing the liquid metal in the mould immediately after casting, and in substituting a hydraulic press for the hammer, in the subsequent forging of the metal.

The flask is made of steel and is built up of sections united by broad flanges bolted together in such numbers as to accommodate the length of the ingot to be cast. All moulds are cylindrical in form. The interior of the flask is lined with square rods of wrought iron, longitudinally arranged, which form when in place a complete cylindrical interior surface. Where the square edges of these rods meet they are cut away, both on the inside and on the outside, and, at intervals of two inches, small holes are drilled through betweeen the rods, forming a channelway from the interior to the exterior for the passage of gas and flame. The interior is then lined with moulding composition. The flange at the bottom of the flask, as well as that at the top, is perforated with small holes which act as a continuation to the perforations between the segments of the lining for the escape of gas.

The casting is made directly into the mould from the top. On the completion of the casting, the mould is moved (by means of a railway at the bottom of the casting-pit, which is a deep trench running parallel to the position of the furnaces) to a position under the movable head of the press, which is allowed to descend until the tup is in contact with the metal in the mould, and in this position it is locked; a shower of metal is induced, which ceases almost as soon as commenced, by the complete closing of the mould. The first impress felt by the metal is due to the weight of the head of the press alone. This pressure is gradually increased from below by hydraulic action, applied by four rams upon the table on which the flask rests, until the pressure exerted amounts to 6 tons per square inch. The interval from the commencement of the pressure until the maximum is reached varies with the size of the ingot, being for a 45-ton ingot as much as 35 minutes. During this time the flow of gas and flame from the apertures in the flanges of the flask, at top and at bottom, are continuous and violent, exhibiting the practical effect of the compression. This pressure is applied by the direct action of steam and pumping engines, and is indicated by a dial. At the end of this time the pump is taken off, and a uniform pressure of about 1,500 pounds per square inch is established by attaching an accumulator to the press, and allowed to remain until the metal is sufficiently cooled to insure no farther contraction in the mould.

The contraction in length in the mould during the action of the pump, while the maximum pressure is being reached and sustained, amounts to one-eighth of the length of the ingot. After this effect has been produced, there is no farther advantage derived from the pressure in the way of eliminating impurities, but the contraction, in cooling, still goes on and the pressure by the accumulator is considered necessary in order to follow up the metal as it contracts, for the purpose of preventing cracks being inaugurated at the end and on the exterior of the ingot by the adhesion of particles of the metal to the sides of the mould.

When cooled and reheated, the ingot is brought under the influence of the forging-press. This press is hydraulic, with a moving head having the main hydraulic cylinder fixed in it, and it is provided with an arrangement of mechanism for raising and lowering the moving head of the press and for locking the same in any desired position.

The press has four hollow pillars screwed part of their length, which are attached to the base of the press by nuts. On the top of the pillars is fixed a cast-iron head or table supporting two hydraulic lifting cylinders, the rams of which are fitted with cross-heads carrying four suspension bars. These bars pass through the moving head, and are connected at the lower ends by cross-bars, which are fastened to the pressing ram. The moving head works between the base and the top or fixed head of the press, and is raised or lowered by the admission or exit of water from the underside of the rams of the lifting cylinders. The moving head can be firmly and rapidly locked at any height from the base which may suit the work to be operated upon. The moving head, as already mentioned, carries a forging or compressing cylinder, which forces a ram down upon the work. By attaching the compressing cylinder to, and making it part of, the moving head, a short stroke can be employed when forging objects which may vary in size from a few inches to several feet in diameter.

This in general terms explains the working of the ram. The effect produced by it requires to be seen in order to be thoroughly appreciated, and is altogether different from that produced by the hammer. The heated ignot resists the blow of the hammer, but the insinuating, persevering effort of the press cannot be denied. The longer time (several seconds) during which the effort lasts is a great element in its successful effect. As pressure succeeds pressure the stability of the particles is thoroughly disturbed and a veritable *flow* of metal induced, which arranges itself in such shape as the pressure indicates; the particles are forced into closer contact and the whole mass writhes under the constraint which it is impotent to resist.

The Board witnessed the operations of casting followed by that of liquid compression, the enlarging of hoops, the drawing out of cylinders, and the forging of a solid ingot. The unanimous opinion of the members is that the system of Sir Joseph Whitworth surpasses all other methods of forging, and that it gives better promise than any other of securing that uniformity so indispensable in good gun metal.

The latest exhibition of the wonderful character of the Whitworth steel has attracted great attention, and may be stated as indicating the present culmination of his success. From a Whitworth 9-inch gun, lately constructed for the Brazilian Government, there was fired a steel shell, which, after perforating an armor-plate of 18 inches of wrought iron, still retained considerable energy. The weight of the shell was 403 pounds, the charge of powder 197 pounds, and the velocity about 2,000 feet. The shell is but slightly distorted. The tests of the metal of which it was made show a tensile strength of 98 tons per square inch and a ductility of 9 per cent.

Basic Process.—The manufacture of steel as treated in the Bessemer converter came under the particular notice of the Board at the works of Sir Henry Bessemer, in Sheffield, but nothing in the practice deserving of special remark was observed with the exception of the use of a mechanical stirrer, which is inserted into the molten metal in the ladle after the recarburating charge of spiegeleisen has been added. The stirrer is, in form, a two-bladed propeller on the end of a vertical shaft, actuated by a geared engine of 6 horse-power, conveniently placed at the side of the casting pit. The revolutions of the stirrer have the effect of more thoroughly incorporating the spiegeleisen with the charge, disseminating it throughout the mass.

No product of the Bessemer converter has yet been found to answer all purposes for gun construction; it has been used with success for

hoops for light guns, but it is deficient in the hardness required for tubes and has the reputation of want of uniformity. Extensive experiments were made in France several years ago with this metal, with a view to adopting it for gun construction, but failure after failure caused the abandonment of the effort. Those who are laboring to perfect this process insist that great improvements have recently been made, and that the character of want of uniformity is no longer deserved. Should final success attend these efforts, there will be a probable future of great usefulness opened up for the numerous phosphoric ores in the United States, as the Bessemer converter is found to be a most convenient means of applying dephosphorizing elements to these ores when in a state of fusion. For the purpose of investigating this matter, the Board visited the extensive works of Bolckow, Vaughan & Co., near Middlesbrough, where, under the guidance of Mr. E. Windsor Richards, the manager, the manufacture by what is termed the "Basic Process" was witnessed.

This immense establishment is located at Eston, 5 miles from Middlesbrough, and there is evidence of great executive ability guiding the details of its conduct. The company owns very extensive territory adjoining the works and tributary mining districts of coal and ore, and employs fourteen thousand men. At Eston there are twenty-six blast furnaces; 11,000 tons of pig-iron are cast per week, and, in addition to other fuel, there is a weekly consumption of 13,000 tons of coke; 8,000 tons of coal and 7,000 tons of ore are raised per day.

One point may be mentioned in connection with the manufacture of steel rails at this establishment. The iron is not cast into pigs, but is carried direct from the blast furnace to the Bessemer converter; after casting, the ingot is removed at the earliest possible moment from the mould, and after a short reheating is carried to the rolls, from which it comes out in the form of a finished rail, the whole operation being completed in one heat.

Ten Bessemer converters are in operation, six worked by the Basic Process and four on the usual Acid Process, with a siliceous (ganister) lining.

In the Basic Process the converter is lined with a mixture of dolamite (magnesia limestone), calcined, pulverized and incorporated with coal-tar to make it pasty. The converter is taken to pieces and lined with this mixture 18 inches thick. Before lining the bottom, through which are the perforations for the passage of air during the operation of blowing, long rods are inserted in the holes and the mixture is packed around them. When this operation is completed the rods are removed, leaving holes through the bottom lining. The pieces of the converter are then assembled, and a fire is lighted on the inside to burn out the coal-tar on the inner surface; the whole lining then has a set. One lining of the sides is good for 40 or 50 blows; one lining of the bottom is good for 10 blows.

The converter being in place and heated, a charge of pure, common lime, unslacked, is introduced (15 per cent. of the charge of iron). The molten metal, brought from the blast furnace, is then poured in and the blow commenced. When the phosphorus is removed, which is ascertained by mechanical tests, about three-fourths of the charge is emptied into the ladle, in which ferro-manganese has been previously placed; a charge of 4½ per cent. of molten hematite, imported from Spain and containing from 2½ to 3 per cent. of silicon and a mere trace of sulphur and phosphorus, is then brought from a cupola furnace and poured into the ladle, causing a violent ebullition; this goes on for a

time, more ferro-manganese being added, if necessary, to prevent red-shortening. When the boiling ceases, 4½ per cent. of spiegeleisen is poured into the ladle, which is then brought again under the converter and receives the rest of the charge. The casting is then made from the ladle.

The ore used in this process is of very inferior quality; it is called Cleveland stone, has 42 per cent. of iron and high phosphorus, the pig containing 1½ per cent. Being very low in silicon it does not destroy the lining, which would be the case if silicon was high. The object of the lime is to take up and hold the phosphorus in the slag. The phosphorus is increased in the charge by adding some of the old slag, making the proportion of phosphorus 1.75 per cent. The amount of silicon in the iron is from 0.75 to 1 per cent. During the operation of blowing this silicon is the first to disappear; the carbon is then consumed, immediately after which the phosphorus passes into the slag. This operation requires about 2½ minutes and is timed from the moment the collapse or falling of the flame shows that the carbon is burned out.

Mr. Richards stated that previous to the introduction of the charge of hematite during the operation there was a want of uniformity in the results; that sometimes there would remain traces of phosphorus, but that the introduction of the pure hematite, which has only a trace of phosphorus and is high in silicon, before casting gives such stability to the mass as to prevent the slag from parting with any of the phosphorus it has taken up; the silicon also in the hematite is oxidized in calming down the steel, and it also goes into the slag. The introduction of the hematite also makes it possible to halve the ordinary charge of spiegeleisen, which, as spiegel is costly, cheapens the operation.

The Basic Process, thus briefly sketched, has for its object the utilization of inferior ores. It is the only one now known by which this injurious element, phosphorus, can be eliminated. For guns the natural prejudice would be against metal made from ore which was originally defective, but the operators of this system hold that their product is as good as if made from pure ore. Whether it will ever be used for gun metal will depend upon the confidence that it may inspire in the future, but the problem of its application for general purposes has been successfully solved.

PRESENT CONDITION OF THE ENGLISH ARTILLERY.

It is well known that the essential characteristics of the Woolwich gun were that it was a muzzle-loader and depended for its strength upon wrought-iron coils. The security of muzzle-loading and the safety derived from the wrought iron used in the construction of the gun have been claimed as advantages over other constructions.

At the time of the visit of the Board to England it was found that a great change had taken place in the opinions of the English artillerists on these two points, and that the military and naval services were changing the character of their armaments. The first effort was directed to the substitution of the breech-loading system. This was induced by the increasing difficulties attending the loading of large guns at the muzzle both on shore and at sea. Adherence to the practice of muzzle-loading had imposed much additional expense for machinery necessary for manipulation, and the ever increasing length of guns and weight of projectiles complicated the difficulties. It was determined that attention should be given to the question of applying the breech-loading principle to guns, and in 1879–'80 plans were made for such

constructions and the experiments were inaugurated which promise to involve an entire change in the armament of the country.

Although the idea of introducing the system of breech-loading seems to have been forced by the difficulties attendant upon the use of large calibers, the effort is now being made to apply the change to all calibers. The Board found that in the gun factory at Woolwich guns of all calibers were being fitted on the breech-loading system.

One of the first experiments tried was with a 12-inch 43-ton gun, manufactured at Woolwich, which was built of wrought-iron coils and fitted with the French fermeture, necessarily inserted in the rear of the steel tube. Good ballistic results were obtained, but the construction of the gun does not seem to have given satisfaction. At the same time some experiments with 6-inch breech-loaders were carried on. These were built up in the same way; several failed, some of them after being fired with battering charges. The reasons assigned refer to bad metal and to errors in manufacture. These failures, however, seem to have convinced the authorities that it was not wise to continue the use of coiled wrought-iron hoops and breech-pieces, and the Board finds that with the adoption of the system of breech-loading there is a positive move to the use of steel for all parts of their gun construction.

The guns under construction at the Woolwich Gun Factories indicate that this conclusion has been accepted by the Government, though the differences perceptible in some of them show the gradual growth of the developed idea. For example, though the 12-inch 43-ton gun of latest order is composed entirely of steel, there are other guns of the same caliber and weight which have a portion of their hoops made of wrought-iron coils. There is no doubt, however, that the use of wrought iron and the system of muzzle-loading have been abandoned.

In addition to the 12-inch 43-ton steel guns, there are in hand 13-inch 62-ton steel guns; also 10-inch 26-ton steel guns designed to throw a projectile of 500 pounds with an initial velocity of 2,100 feet. Much interest is also felt in the success of the 9.2-inch 18-ton steel gun, which is designed to supersede in sea service the present 10-inch 18-ton wrought-iron muzzle-loader. Four 8-inch 11½-ton steel guns are being manufactured in the Royal Gun Factories; two of them will be 30 calibers in length and two will be 26 calibers in length, the shorter being intended for sea service. Breech-loading guns of 6-inch, 5-inch and 4-inch calibers are also now constructed of steel.

In this transition from wrought iron to steel it must be particularly noted that the change as thus far made in large guns consists in the substitution of coiled steel for coiled wrought iron; the reason for taking this intermediate step being the want of experience at the Royal Gun Factories in the manufacture of solid steel hoops, and the greater certainty of the manufacture of the steel coils. The superiority in strength of the steel coil over that of wrought iron is positively claimed by the superintendent. Jackets (breech-pieces) and hoops of forged and rolled steel are to be used as soon as practicable.

What has been recognized by the world as the Woolwich system no longer exists in practice. In its place we find the Vavasseur design, a gun composed of a steel tube, with a steel jacket (breech-piece) supplemented by superimposed layers of steel hoops. This change has been brought about by public opinion, which has asserted itself in condemnation of the material and the system of construction so long in use.

Material.—It is stated by a very high authority that wrought iron welded into such large masses, as are required for the Frazer system, loses it fibrous character and becomes highly crystalline.

The use of the coiled steel hoops, adopted as a temporary expedient at Woolwich, is objected to by high authorities, who, while allowing that steel of an extremely mild quality might be used for welded coils, say that it would be no better than iron, and that at the point of welding no greater strength than that due to iron can be obtained.

All authorities concur that steel, superimposed in layers over an inner barrel, is the best material for ordnance and the preponderating testimony favors its manufacture by the Open-Hearth Process. This is not due to any objection to crucible steel, which has heretofore been used for all gun-tubes, but because the results of the Open-Hearth Process are equally satisfactory and cheaper. Even those who insist in retaining crucible steel for tubes are willing to adopt the Open-Hearth steel for jackets and hoops.

There is a difference of opinion as to the mode of manufacture of the hoops and jackets. All agree that small hoops should be rolled after having been forged into a ring shape from a cast ingot; but for larger hoops and jackets it is recommended by some that they should be cast hollow and then forged, and by others that they should be cut from a solid ingot and forged; while still another authority thinks that hoops and jackets of large size should be bored out of the solid after forging.

Construction.—In the latest designs for steel guns the system of Mr. J. Vavasseur has been adopted. This consists of a tube as thin as is consistent with strength; a long jacket shrunk on to provide longitudinal strength; and layers of superimposed cylinders or hoops shrunk on, the number of layers varying with the size of the gun. The thin tube develops more thoroughly the principle of a built-up gun, and is less liable to contain concealed defects. It makes the ultimate strength of the gun less dependent on its integrity.

Sir William Armstrong advocates a greater number of layers than Mr. Vavasseur or the superintendent of the Royal Gun Factories. The latter agree that the thickness of the layers should not be reduced to a point where the mass is not sufficient to compress the structure under it in process of cooling.

Sir William Armstrong considers that he increases the end strength of the layers of his guns by interposing sheet copper between the surfaces, and states that copper has been used in this way at Elswick for two or three years. The superintendent of the Royal Gun Factories and Mr. Vavasseur object to the use of copper as rendering the compression due to shrinkage uncertain in amount. They prefer to rely for end strength on hooking the layers together. In their latest designs the chase of the gun is not reinforced, but depends for its strength on the thickness of the steel tube. Sir William Armstrong, however, considers it desirable to extend the hoops to the muzzle of the gun to provide against the possible premature bursting of a shell in the bore.

The *pressures* to which the guns will be permitted to be habitually subjected will not exceed 18 tons to the square inch.

The propriety of lining the tube with a thin steel lining is being closely considered for the purpose of providing a plan for renewing the portions of the metal scarred by firing without having to resort to retubing. There is no doubt that experiments will be made in this direction.

Breech-Closing.—All the authorities in England now advocate the breech-loading system for cannon. The interrupted screw, commonly known as the French system, is preferred and has been adopted at Woolwich. In the heavier guns, at least, the breech screw will not engage in the tube, but in the cylinder immediately surrounding it, thus relieving the tube from that portion of the longitudinal strain which

tends to blow out the breech. The number of interruptions increases with the caliber; there are four in the breech mechanism of the 12-inch 43-ton gun.

Gas-Check.—The de Bange gas-check has been adopted at Woolwich and is preferred by Mr. Vavasseur. It is considered as complying more nearly than any other with the conditions required of a perfect gas-check. It requires no seat to be prepared for it in the chamber, is not liable to derangement, and does not require perfect accuracy in its manufacture. Sir William Armstrong adheres to the Elswick cup, as opposed to the Broadwell ring, and objects to the de Bange gas-check because of the additional length of gun required; in the 12-inch 43 ton gun this amounts to 6 inches.

Vent.—The vent is in the axis of the gun and the escape of gas through the orifice after firing is checked by a device by which a plug is drawn into the neck of the primer by the action of pulling the laniard attached to the friction tube.

Form of Chamber.—At the Royal Gun Factories it is considered that the best results are obtained with chambers not more than $3\frac{1}{2}$ diameters in length, and with an opening the full diameter of the chamber. Sir William Armstrong, though preferring a long, narrow chamber as being favorable to strength of tube, thinks that under the present aspect of the powder question the short, wide chamber, with full-sized opening, must be adopted.

Rifling.—All the authorities except Sir Joseph Whitworth, who adheres to the polygonal system, agree that the grooves should be numerous and shallow. The rifling is polygroove; the grooves are cut to a depth of 0.05 inch, and their non-driving edges are sloped to diminish the scoring. The twist is an increasing one (from about 1 in 120 calibers to about 1 in 35 calibers) for about half the length of the rifling; the other half, to the muzzle, being a uniform twist of about 1 in 35 calibers. The number of grooves is determined by the caliber and is the product of 4 and the diameter expressed in inches; thus, the 12-inch gun has 48.

Rotating Rings.—The Vavasseur rotating ring is now adopted by Woolwich and Elswick, the dimensions being determined by experiment. Mr. Vavasseur lays great stress on the position of the rotating ring on the projectile. He states that it should be at the center of percussion with respect to the front bearing.

Wire Construction.—The employment of steel ribbon or wire in gun construction has been more or less considered since 1855, when Mr. James A. Longridge brought to the notice of the War Office his proposed method of increasing the strength of guns by this means. Some experiments were made, but they were not satisfactory. Of the strength that was given circumferentially there was no doubt, but the difficulties of providing it longitudinally were so great that the subject was dropped at the time. Recently, however, the matter has been taken up by Sir William Armstrong, who has manufactured several wire guns.

A 10.2-inch gun of this manufacture has been purchased by the War office and is now under trial. In this gun longitudinal strength is obtained by disposing some of the wire lengthwise around the tube, and some very satisfactory experiments have been made with it. The gun weighs 21 tons, is 25 calibers long, and the following present some of the particulars of the last reported firing:

Charge of powder	pounds..	220
Weight of projectile	do....	404
Muzzle velocity	feet..	2,160
Pressure per square inch	tons..	17

A 6-inch breech-loading gun and a 6.3-inch muzzle-loading howitzer manufactured by the same firm are also about to be tried. In these the longitudinal strength is entirely dependent on the steel tube. The same firm is manufacturing several 6-inch breech-loading guns in which the longitudinal strength is partially provided for by a jacket, the wire wrapping being only called upon to provide circumferential strength.

The Royal Gun Factory has taken up the subject and has matured designs for experiment on a large scale. In its designs the longitudinal strength is obtained by means of steel segmental hoops placed between layers of wire.

The following is the present state of the wire-gun question in England:

Manufacture of Sir William Armstrong:
Under trial, 10.2-inch breech-loading gun.
To be tried, 6-inch breech-loading gun, 6.3-inch muzzle-loading howitzer.
Manufacture of Royal Gun Factories:
Under manufacture, 10-inch breech-loading howitzer.
Recommended for manufacture, 15-inch breech-loading gun of 63 tons.

Opinions vary as to the form, size and other characteristics of the wire. One authority recommends square wire for the first six or eight coils, gradually increasing the size of the wire as the coils proceed outwards. This authority states that the higher the elastic limit the better, the breaking strain and power of elongation being of comparatively small importance, and that the wire should never be strained up to its elastic limit. Another authority recommends a flat wire of 100 to 110 tons breaking strain wound on a tension of 60 tons for the inner and about 70 tons for the outer layers, the longitudinal strength to be provided by the inner tube of the gun and by steel segments divided longitudinally, but, when put together, forming a tube. Another authority states that the full benefit of wire cannot be obtained unless strained beyond its elastic limit. Another authority prefers wire of a circular section, it being impossible to keep any other shape to gauge. For heavy guns he would use wire of 0.0984 section, with a breaking strain of about 125 tons, and an elongation of about 2 per cent. This authority says that the elastic limit of the wire should not be passed in winding it on. He estimates that there would be a saving in weight of about 30 per cent. on the breech portion of the gun, and more certainty of manufacture than with steel hoops.

FRANCE.

SOURCES FROM WHICH THE ARMAMENT OF FRANCE IS SUPPLIED.

Previous to the Franco-German war of 1870, it was the custom in France to confide all matters relating to cannon to the artillery corps of the army and navy; aid from private sources was neither sought nor offered; much secrecy was observed in all things relating to the business of ordnance; admission to the Government foundries was obtained with difficulty, and the experimental ground at Gâvre, with rare exceptions, was closed to all applicants.

For army purposes, the gun factories at Bourges, Puteaux and Tarbes supplied all demands, while for the use of the navy the foundries of Ruelle and of Nevers, and the gun factories attached to them, provided the entire armaments.

With the advent of the war came the proof that a close corporation, such as was constituted by the system heretofore adopted, could not work to the best advantage of the country; and, with the return of

peace and the necessity of re-armament, came a revolution of ideas which has led the Government to modify its practice.

It was recognized that the Government must have under its control some establishments purely governmental; but that, in order to provide for all contingencies as well as to prevent official ideas from running too much in a groove, it was desirable to encourage private industries, so that a spirit of emulation might be excited by competition and a channel afforded through which new ideas and inventions might reach the national works. The adoption of this course was made the more imperative in consequence of the new departure in gun-metal, and this opened the way to the encouragement of the steel industries of the country.

The plan thus decided on has been consistently carried out. The Government gave assurances to the private companies which induced them to expend the funds necessary to erect new and suitable tools, both for the casting of the metal and the fabrication of the guns.

The result of this action can be appreciated by reference to the following list of private companies which are now employed in providing armaments for the Government.

STEEL MANUFACTORIES PRODUCING STEEL UP TO TUBES FOR 16-CENTIMETRE GUN.

Jacob Holtza & Co.	Unieux (Loire).
Marrel Frères	Rive de Gier (Loire).
Société des Acieries et Forges de Firminy	Firminy (Loire).
Compagnie des Forges et Acieries de St. Etienne	St. Etienne.

STEEL MANUFACTORIES PRODUCING STEEL UP TO TUBES FOR 42-CENTIMETRE GUN.

Henri Schneider & Co	Le Creusot.
Acierie de la Marine	St. Chamond.

PRIVATE COMPANIES HAVING PLANT OF GUN FACTORY.

Henri Schneider	Le Creusot.
Cail & Co	Paris.
Société des Forges et Chantiers de la Mediterranné	Havre.
Compagnie de Fives-Lille	Fives-Lille (Nord).
Société Anonyme de Constructions Navales du Havre	Havre.
Acierie de la Marine	St. Chamond.

STEEL MANUFACTORIES PRODUCING ARMOR PLATES.

Henri Schneider & Co. (forged steel)	Le Creusot.
Acierie de la Marine (compound)	St. Chamond.
Marrel Frères (compound)	Rive de Gier.
Chatillon et Commentry (compound)	Montluçon.

The compound plates are manufactured under the patent of Mr. Wilson, of Charles Cammell & Co., Sheffield, England.

All the gun-carriages for the navy and for coast defense are made at private works.

The above lists illustrate the immense increase of resources that the Government has obtained by encouraging private industries and they contribute an important historical chapter for the instruction of a Government about to provide an armament for its military services.

The following is the list of the Government works manufacturing for the army, viz:

(1.) Fonderie de Canons à Bourges, in the center of France. At this place steel guns are made of 90 millimetres, 155 millimetres, 190 millimetres, and 240 millimetres; also rifled mortars of 220 millimetres.

(2.) Atelier de Construction à Tarbes, in the Hautes Pyrenées, in the southwest

part of France. At this place steel guns are made of 90 millimetres, and 120 millimetres; also carriages for field and siege guns.

(3.) Atelier de Construction de Puteaux, near Paris. At this place all the steel mountain and field guns of 80 millimetres are made; also siege guns of 120 millimetres, and the Hotchkiss revolving cannon for flank defense.

(4.) Gun carriages, limbers, &c., are made at Government shops at Vernon, Avignon and at Angers.

Gun-carriages are also manufactured for the army at private works.

Bourges.—The gun factories of the army fabricate no guns above the caliber of 24 centimetres, and it is only at Bourges that army guns of this caliber are constructed. At the private establishments mentioned above the work of fabrication has been carried as high as 34 centimetres, but the advantageous working capacity of the factories does not extend beyond the 24-centimetre gun.

Ruelle.—At the "Fonderie à Ruelle" all the constructive force of the marine artillery has been concentrated, and here all the largest guns are made. It contains the most remarkable collection of tools of the age. They are designed for guns of 34 centimeters and upwards, and have a capacity for handling guns of 160 tons in weight and 60 feet in length. The shop in which these tools are placed is about 450 feet in length and 131 feet in width, having a height of 85 feet at the central peak of the roof. At one end is the tubage pit, in which the gun tube is placed upright to receive the hoops. The bottom of this pit is at a depth of 85 feet below the floor. It is excavated in a rectangular form and is divided into four stories, contracting in area as the lower level is reached; at each story or landing place, the opening can be floored over to accommodate the work of hooping any length of tube. The heating furnaces are on the first story below the floor. The tools already in place are the following, but there is room for fully a dozen more of similar character:

Two turning lathes, capable of turning guns 15 metres long. These can be increased in length 10 metres.

Three boring machines for same.

One rifling machine for same.

Two smaller boring machines with adjustable connections for turning.

Two other machines for performing all the details of the work about the breech, for receiving the fermeture, turning the screw, slotting, piercing holes, &c.

Two movable cranes; one of 100 tons, the other of 30 tons capacity.

The contractors for these tools were Varall, Elwell & Middleton, Paris. The plant has cost millions of francs, and five years elapsed from the giving of the order to the setting up of the tools. A large portion of the time charged to the manufacture must be credited to the preparation of designs, no tools of their size and great capacity having been before conceived.

Taking the above short notice of the works at Ruelle in connection with what has been stated on the subject of private industries, it will be seen how well all the requirements are provided for a joint production of cannon by the Government and private parties. The latter assist up to a point justifying on their part a reasonable outlay of money for a plant, and the Government, though working in this common field as well, yet reserves to itself all the more onerous charges involved in the manufacture of the heaviest ordnance.

It seems as if in France the happy mean has been reached by which the Government and the private industries can work harmoniously towards the accomplishment of a national object.

In a combined system of this kind, it is very important to be assured that there exist mutual checks which act to prevent the one party im-

posing improper or hard terms on the other. The board is not without evidence of the existence of these salutary checks in France.

A short time since the Government deemed it necessary to increase its armament by 300 additional guns, and decided that certain additional tests should be required of the metal for the tubes. When the provisions of the proposed contract were made known to the steel manufacturers, they resisted the requirements as being too hard and insisted on the acceptance of such steel as had been previously supplied; but to this the Government would not accede. Finding them determined in their resistance, the Government made inquiries abroad as to the possibility of securing the metal it required, and, finding that a foreign manufacturer would undertake the contract, a promise was given to him that he should receive the order. The steel manufacturers of France, hearing that the order was likely to be given to a foreign firm, endeavored to arouse a national feeling on the subject to constrain the Government to make the purchase in France, but to no effect; and they finally proposed to accept the Government proposition. But the minister had already given his word to the foreign manufacturer and the contract was lost to France. In this instance both parties, the Government and the private companies, acted within their independent rights, but neither could compel the other. This exhibition of effective counterpoise is a good proof of a happy adjustment of forces.

CONDITION OF STEEL MANUFACTURE.

Since the termination of the Franco-German war of 1870, and in the course of the re-armament of the country, the Government has given every encouragement to private industries to justify them in incurring the expense of establishing plants at various points to assist in the construction of guns; and by embarking largely in the fabrication of *steel* cannon it has given a great impetus to the manufacture of this important material. The numerous works that can produce metal suitable for tubes and hoops for field-pieces have been mentioned. These establishments have made a study of the subject of gun-metal, and, so far as their facilities for forging reach, can all supply the demands that the country can make upon them.

For tubes and hoops, however, for large guns, requiring massive forgings, the supply is limited to the works of the "Compagnie de l'Acierie de la Marine" at St. Chamond, and to those of H. Schneider & Co. at Le Creusot, the former having a steam-hammer of 80 tons, and the latter one of 100 tons weight.

There are some establishments, notably at St. Etienne, where crucible steel of a high order is manufactured for purposes of trade, but no effort is made to utilize it for gun purposes.

St. Chamond.—The cast steel used for cannon in France is manufactured by the Open-Hearth Process with Siemens' furnaces. This process is combined with the rotating bath of M. Pernot at St. Chamond, where three 25-ton and two 12-ton Pernot furnaces give a capacity for casting an ingot of 100 tons.

The ingots cast here for the 42 centimetre 75-ton guns are of 75 tons weight; the tube, after rough boring and turning, weighs about 35 tons.

The tempering-pit is a large excavation 15 metres deep. At one extremity is the furnace where the tube is placed erect and heated. At the other is a cylindrical excavation, reaching to 15 metres below the floor of the pit, where is placed the tank containing 100 tons of colza oil into which the tube when heated is lowered rapidly.

Le Creusót.—The most important steel works in France are situated at Le Creusot and bear the name of the location in which they are situated. These works have advanced year by year in importance and in magnitude since their purchase by Mr. Eugene Schneider.

This gentleman's death, in 1875, was a source of mourning to the whole town, the inhabitants of which looked up to him as a father. The grateful people have erected to his memory a monument in the market square.

Under the administration of his son, Mr. Henry Schneider, the fame of the products of the works has been enhanced, and the proportions of the establishment have been much increased. The whole number of workmen now employed here and at other points amounts to 15,000; and it is the great center of industry of the adjoining region. At no other place in the world is steel handled in such masses.

It would be foreign to the purpose of this report to dwell on the many objects of commerce which are supplied from these works, but it is safe to say that no proposed work can be of such magnitude as to exceed the resources of the establishment.

For the preparation of metal for cannon and armor-plates Le Creusot is thoroughly equipped. The iron is produced on the premises from the purest imported ores, and the manufacture of the steel is carried on by the most approved application of the Open-Hearth system with the Siemens furnace; the chemical and mechanical tests are such as to satisfy the most exacting demands of careful Government officials, and the executive ability apparent in all the departments and the evident condition of discipline that pervades the whole establishment inspire confidence in the productions of the labor.

The capacity for casting steel is represented by seven open-hearth furnaces of 18 tons each, equal to 126 tons; and the process of casting large ingots is a model of order and security. Ladles capable of holding the contents of one furnace, mounted upon platform cars, are successively filled at a previously determined interval of time and run on railways to a convenient position over the mould; before the first ladle is exhausted the supply from the succeeding one has commenced to run, and so on to the completion of the casting, the supply to the mould being uninterrupted during the entire process. The precision with which the several ladles are brought into position in succession makes it entirely unnecessary to provide a common reservoir into which all the furnaces may discharge. By this process the casting of a 45-ton ingot, which was witnessed by the Board, was effected in 23 minutes.

The process of tempering the gun-tubes was also witnessed by the Board. The excavation of the pit is, as at St. Chamond, 15 metres deep, with the furnace at one end and the oil tank (100 tons) at the other. One side of the upright furnace is constructed in the form of a door, which, by a convenient arrangement for swinging, is made to turn on its hinges. Thus, when the tube is raised to the right temperature, it is seized by the traveling-crane, the door of the furnace swung open, and the tube at once advanced to the tank in which it is immersed.

All tubes are immersed in oil the second time, but at a temperature much below that to which they are raised at the first immersion. This process constitutes the annealing after tempering.

The manufacture of steel-armor plates is a specialty of Le Creusot, which is engaged in an active competition with the manufacturers of compound armor. Plates up to 60 centimetres in thickness and 3 metres wide are forged here; they are tempered after forging, but what subsequent treatment they receive was not explained.

The tempering-pit for the plates consists of an excavation of convenient size, in the center of which is placed a tank containing 180 tons of oil. At the four corners of the pit are furnaces in which the plates are raised to a proper temperature. When sufficiently heated a plate is seized by a walking-crane and immersed in the oil.

Hoops for cannon are manufactured here in large quantities. They are cut from solid ingots, and those for guns up to 24 centimetres are rolled like railway tires; those for larger calibers are forged on a mandrel. Jackets of large size are also manufactured; these are made from solid ingots, which, after being forged, are bored out.

At Le Creusot a remarkable test of hoops was witnessed which exemplifies not only the excellence of the manufacture of the steel but also the exacting character of the French requirements. The hoops for naval guns are made with the interior surface slightly conical. When forged, turned and brought under a hammer, a standard mandrel of steel, conically shaped to suit the form of the cone in the hoop, but of a slightly increased diameter, is introduced, the smaller end of the mandrel being able to enter the larger end of the hoop. The mandrel is then forced in by the hammer until its lower edge has passed through the hoop. The blows are then made to operate on the upper edge, detaching it from the mandrel. Careful measurements are taken of the diameter of the hoop before and after this test, and it is required that the measurement subsequent to the operation shall show that the hoop has partially, but not entirely, returned to the diameter that it had before the entrance of the mandrel. This would show that there is left to the metal a small margin within its elastic limit. A system of manufacture which can comply with such a refinement of exactitude must be very precise.

Perhaps the most striking feature at Le Creusot is the forge, where is assembled an array of steam-hammers not equaled in the world, viz:

One 100-ton hammer with a fall of 5 metres.
One 40-ton hammer with a fall of 3 metres.
One 15-ton hammer with a fall of 3 metres.
Two 10-ton hammers with a fall of 2½ metres.
One 8-ton hammer with a fall of 2½ metres.

As the 100-ton hammer at these works is the largest in the world, some particulars concerning it will be appropriate.

The foundations are composed of a mass of masonry laid in cement resting on bed rock, which occurs at a depth of 11 metres, an anvil block of cast iron, and a filling in of oak timber designed to diminish by its elasticity the vibrations resulting from the blows of the hammer. The masonry foundation presents a cube of 600 metres. Its upper surface is covered with a layer of oak about 1 metre in thickness, placed horizontally, on which rests the anvil block.

At the Perm foundry in Russia the anvil block for the 50-ton hammer is made in one piece, moulded and cast in the spot it was destined to occupy. Its weight is 622 tons. At Le Creusot, however, this idea was not approved and it was determined to construct the block in six horizontal courses, each bedded upon plane surfaces. Each course is formed of two castings, except the upper one, a single block, which weighs 120 tons and supports the anvil. Thus formed in 11 pieces, it is 5.6 metres high, 33 square metres at the base and 7 square metres at the top. Its entire weight is 720 tons. The space between the block and the sides of the masonry in which it rests is filled in solidly with oak. The block is thus independent of the frame of the superstructure.

The legs of the frame, inclining towards each other in the form of an

A, are secured at their bases to a foundation-plate imbedded in the masonry. They are hollow, of cast-iron, and of rectangular cross-section, each leg in two pieces joined midway of their length by flanges and bolts. The legs are also bound together by four plates of wrought iron which, at the same time, hold the guides. The height of the legs is 10.25 metres and their weight, with the guides, 250 tons. The binding plates weigh together about 25 tons, and the foundation-plates 90 tons.

The entablature of the frame-work weighs 30 tons; on it is placed the steam cylinder, single acting, made in two pieces, each 3 metres long, united by flanges and bolts. The diameter of the cylinder is 1.9 metres, giving a surface of 27,345 square centimetres (deducting the section of the rod, which is 36 centimetres in diameter); which, for 5 atmospheres, gives a pressure under the piston of about 140 tons. As the weight of the hammer is 100 tons, it is evident that it can be raised with great velocity.

The stroke of the piston in the cylinder is 5 metres. This height of fall, multiplied by the 100,000 kilogrammes of the mass, gives a working ing force of 500,000 kilogrammetres, or about 1,640 foot tons. The width between the legs is 7.5 metres, and the free height under the cross-ties 3 metres, thus providing ample space for manœuvering large masses of metal.

The entire height of this colossal structure from the base of the masonry foundation to the upper part of the steam cylinder is 31 metres (102 feet), but notwithstanding this unfavorable condition for stability and the enormous effect resulting from a shock of 500,000 kilogrammetres, everything is so well proportioned that there is but slight vibration.

The workman who manœuvers the hammer is placed on a platform on one of the legs about 3 metres above the floor. He is here protected from the heat reflected from the mass of metal during the operation of forging.

Terre Noire.—The "Compagnie des Fonderies et Forges de Terre Noire, La Voulte et Bességes" is one of the important steel producers of France; and, though its metal has not as yet been received for tubes for large cannon, it has been largely used in the production of shells and hoops. The company claims a specialty in producing cast steel without blow-holes, which requires no subsequent working under the hammer. The mode of manufacture is known as the Terre-Noire Process, and is the result of many years of gradual development. The value of the product has been so far appreciated by the Government as to justify its use for small guns and hoops, and even for trunnion-bands, while the manufacture of steel projectiles is a large item in the yield of the works. The Terre Noire metal is produced in the Siemens furnace, and possesses in the cast state all the necessary qualities for ordinary industrial purposes; it is soft and malleable and is said to be as strong as ordinary steel of the same grade after rolling or hammering. It is claimed that its density is always as high as, and sometimes higher than, that of ordinary forged steel. These statements are supported by facts shown in numerous experiments.

The persevering efforts of the Terre Noire Company to develop this manufacture and the expense attending years of experiment prove their confidence in the principle involved, and the encouragement given during the past two years by the Government shows an appreciation of its merit; further experience may justify the use of the metal more generally in the construction of cannon, and, if it can be made hard enough

for the purpose, it may be used for tubes. It will require exhaustive experiments to induce artillerists to accept in all cases the simply cast metal as a substitute for that forged under a hammer or press; but if a perfect demonstration shall be made of its ability to endure all tests it will open a way to a great economy in manufacture.

In general terms, as stated by Mr. Holley, the object of greatest importance in this process is to keep down oxidation in the bath from the commencement of the operation. For this purpose the furnace must be kept as hot as possible, with a good solid body of flame, but there must be only just enough air admitted to promote thorough combustion.

The process requires an initial bath of pig-iron containing from 6 to 8 per cent. of manganese. Spiegeleisen is the most convenient form for introducing it; but as a spiegel with precisely this percentage may not be at hand, the bath may be formed by taking a richer spiegel and diluting it with a proper proportion of ordinary pig containing no manganese. The greater part of the bath should be made of pig poor in carbon, particularly when highly carbonized materials are to be dissolved. The weight of the initial bath should generally be about 11 per cent. of the whole.

When the bath is completely melted the refining materials are successively added in small quantities. These are preheated and dropped at the deepest part of the hearth in front of the doors. Preheating is employed not only to keep the furnace hot, but to save oxidation. The materials used at this period of the operation are chosen with reference to the quality required in the finished product. For projectiles, the Terre Noire Company generally use Bessemer ingot and rail ends, with sinking-heads from previous projectile charges. These are all high in carbon, and contain some manganese. The proportion of refining materials to the whole charge averages 78 per cent. As soon as one charge is melted another is added, until all are fused, when a series of tests commences. The study of these specimen tests is kept up until the bath is in a condition to receive the final additions. These consist of a special pig (11 per cent. of the whole charge) containing 4½ per cent. of silicon and 3½ of manganese, and also a little ferro-manganese containing 50 or 60 per cent. of the latter. A part of these ingredients is taken up by reactions which prevent the formation of blow-holes; the remainder is left in the metal to impart to it the physical qualities required.

The special pig is charged hot. While it is melting a marked change takes place in the bath, which up to that time has bubbled about as much as in the ordinary pig and scrap operation; it becomes gradually more and more quiet, until its surface is smooth and scarcely broken by small and widely-scattered bubbles. When the special pig is nearly all melted the ferro manganese is thrown in hot. The casting takes place immediately. The metal runs into the moulds without any splashing and no escape of gas is noticed during the casting operation.

Spiegeleisen is used for the initial bath because the manganese it contains, being the most oxidizable of all the materials present, will remove oxygen that may be present in the bath, and will intercept oxygen that tends to enter it, so that the more manganese there is in the slag the less oxygen there will be in the metal below. By testing the slag frequently there is constantly present a delicate test of the oxidation of the bath. If this precaution were not taken, and the oxygen were allowed to go on accumulating in the bath, it would be impossible to tell how much there is of it present when the final additions of silicon and manganese are made, and how much of these substances would be re-

moved in taking up this oxygen. Therefore oxygen must be kept out, so that the whole of the ingredients finally added shall be left to perform their work.

The success that has thus far attended the development of this manufacture indicates a useful and important future for the process.

PRESENT CONDITION OF FRENCH ARTILLERY.

The artillery of the army is under the control of the director of artillery in the war department. All guns for the field and for purposes of siege and position are fabricated under instructions from this office.

The list of guns under these heads, now actually in use, comprises a large number of models and varied constructions. This is the result of the hurried manner in which, before the end of the last war, guns of all available descriptions were collected by the Government. During late years, while the re-arming of the country has been progressing, a systematic method of armament has been adopted; but this has not, up to this time, so far advanced as to justify the exclusion of the old guns from the list of those in actual use. As the number of the new guns, however, shall increase they will be substituted for the old; consequently, in presenting the present condition of the artillery of the army, the old are alluded to only in a general way.

Omitting mention, then, of the bronze smooth-bore and bronze and cast-iron rifled pieces of old date, the following may be stated as the present armament of the artillery of the army:

	Kilos.
80-millimetre (piece de montagne), weighing	105
80-millimetre (piece de campagne), weighing	425
90-millimetre, weighing	530
95-millimetre, weighing	710
120-millimetre (piece de siege et position), weighing	1,200
155-millimetre (piece de siege et position), weighing	2,527
190-millimetre (piece de siege et position), weighing	8,000
240-millimetre, weighing	17,000
220-millimetre (steel rifled mortar).	
Revolving cannon (model of 1879), Hotchkiss.	

These guns, with the exception of the revolving cannon last named, are all constructed on the system of Colonel de Bange, late of the army. In addition to them, the army gun factories are employed in the manufacture of a large number of 24-centimetre guns which have a cast-iron body tubed and hooped with steel. They are made to assist in arming the coast. They are also much more economical than all-steel guns.

The ordnance of the navy is attached to a department in the ministry of marine, called the "Direction of Material." The bureau of the artillery of the navy is one of several bureaus under this "Direction," and is presided over by an officer, "chargé du service technique," who is virtually the chief of naval artillery. This position is filled at present by General Dard, an officer of great eminence in the marine artillery of France.

The list of guns of the marine artillery comprises a large number of calibers; and the variety in their construction shows the growth and development of the idea which has finally resulted in an armament for the navy of guns constructed entirely of steel, including the following calibers, viz: 65 and 90 millimetres, 14, 16, 19, 24, 27, 32, 34, 37, and 42 centimetres. The Hotchkiss revolving cannon also forms an important element in this armament.

Many of these guns, including some of 32 centimetres, are models of

previous years—cast-iron bodies hooped with steel; cast-iron bodies with half tubes of steel and hooped; cast-iron bodies with steel tube extending the whole length of the bore and hooped with steel—all indicating the persistent effort that has been heretofore made to utilize cast iron. The other guns mentioned above are entirely of steel.

The marine artillery is engaged in the construction of a modification of the 27-centimetre and 32-centimetre guns of model 1870, to be called the model 1870–'81. They are to be of cast iron, tubed and hooped with steel; their length will be increased to fire heavier charges than the model 1870, giving a velocity of 530 metres; eight 27-centimetre and twenty-six 32-centimetre guns of this pattern are under construction.

The 37-centimetre and 42-centimetre guns were in hand when General Dard came into his present office, and will be completed. Their weights, respectively, are 72 and 75 tons, and their construction is the same.

Eight 42-centimetre guns are in process of construction, assigned to the following turreted ships, viz: Indomptable, Requin, Terrible, Caiman.

One gun weighing 100 tons has been built by the marine artillery at Ruelle, but it is of 42-centimetre caliber, with the same sized tube as that in the 75-ton gun. It is, in fact, the 42-centimetre gun, with a body of cast iron instead of steel. Being constructed for the purpose of deciding all the ballistic particulars of the 75-ton gun, cast-iron was employed for economic considerations.

The following are accepted by the bureau of marine artillery for the future armaments of the navy, and will be entirely of steel, viz:

	Length in calibers.
65-millimetre	
90-millimetre	
10-centimetre	
14-centimetre shell gun	30
16-centimetre (light), with one row of hoops	28½
16-centimetre (heavy), with two rows of hoops	28½
24-centimetre	28½
27-centimetre	28½
34-centiemtre, 44 tons weight	18
34-centimetre, 48 tons weight	21
34-centimetre, 49 tons weight	25
34-centimetre, 52½ tons weight	28½

Material.—Although the gun factories of the army and marine artillery are engaged in the fabrication of guns with cast-iron bodies, and though Colonel de Bange advocates puddled steel for hoops, the effort to perpetuate the use of cast iron is now definitely abandoned as far as the navy is concerned, and the employment of forged cast-steel will be generally accepted.

Construction.—The army guns are fabricated on the system of Colonel de Bange. This construction requires an oil-tempered and annealed steel tube with hoops shrunk on in such numbers and in as many layers as are necessary to resist the strain brought on them by the charge. The hoops are made of puddled steel, coiled and welded. This construction is carried to the 240-millimetre gun, of which there are very few in the service.

There is a serious effort on the part of the officers of the artillery to introduce a change in the method of construction so as to have the hoops made of forged steel, and it is thought that this may result in introducing a modification so far as to have the rear hoop, in which the breech mechanism is seated, and the trunnion hoop made of forged steel, while the coiled, puddled steel will be retained for the other parts.

There are two constructions of the 34-centimetre gun of 21 calibers; one has a thick tube, with two rows of hoops; in the other, a thin tube is covered its entire length with a jacket of the same thickness as the tube, and two tiers of hoops. These guns are intended to give an initial velocity of 600 metres.

General Dard is experimenting in the direction of a larger caliber, and has under construction a gun of 37 centimetres, of the following dimensions, viz:

Diameter of bore	centimetres	37
Diameter of chamber	millimetres	385
Thickness of tube	do	140
Thickness of jacket	do	142.5
Thickness of hoops (1st row)	do	107.5
Thickness of hoops (2d row)	do	132.5
Total diameter	do	1,430
Total length	do	11,185
Length of bore	do	10,545
Length of breech mechanism	do	640
Weight of gun	tons	72
Weight of tube	do	14.7
Weight of jacket	do	16.4
Weight of ingot for tube	do	20

This gun is entirely of steel and the tube is in one piece. From its great length it is evident that a large charge of powder can be consumed in it, but the proposed weight of charge and projectile is not known.

The construction of the 37 and 42-centimetre guns consists of an inner tube in one piece, on the rear end of which is screwed a short tube accommodating the breech mechanism. The tube is enveloped in a jacket, composed of two pieces hooked together forward of the trunnions and inclosed by two layers of hoops.

The above presents, in a condensed form, the present condition of construction in France. Particulars of most of these guns are published and can be referred to at pleasure. The only new guns to be developed are those of General Dard and Colonel de Bange, both of whom propose a 34-centimetre gun. Some particulars of the Dard gun have been given above.

The de Bange gun is made up of an interior tube and three rows of hoops, and the following are some of the particulars:

Caliber	centimetres	34
Weight	tons	37
Charge of powder	kilogrammes	180
Weight of projectile	do	450
Calculated velocity	metres	610
Outside diameter at breech	millimetres	940
Rows of hoops at breech	do	3
Rows of hoops at muzzle	do	3
Energy expected to be developed per ton of gun	metre tons	230
Weight of carriage	tons	24
Weight of Slide	do	30

The high velocity and great energy claimed are said to be due to some peculiarity of the cartridge. The novel feature, however, in the gun lies in the manner in which it is proposed to insure longitudinal strength by the grip of the hoops on the tube and on each other. The outer surface of the tube presents a series of conical undulations; the interior surface of the first row of hoops corresponds with the form of that portion of the tube which they envelop, and a similar form is carried to the exterior of the hoop, thus continuing the same adjustment of parts to the third layer, the outer surfaces of which are shaped to suit the ordinary form of a gun.

In this system each layer is made to break joint with that below and above it. The inventor is erecting a special tool of his own invention, said to be capable of such modifications as will enable it to perform all the operations of boring, turning, slotting, rifling, &c., for which in ordinary manufacture several tools are required. The developments from this experiment may prove very instructive, and will certainly be very interesting.

Breech Fermeture.—All the French guns are breech-loading and are fitted with the interrupted screw system as modified by Colonel de Bange to suit his gas-check.

Gas-Check.—The de Bange gas-check is universally employed, the tête-mobile of which is made of crucible steel supplied by Thomas Firth & Sons of Sheffield, England.

Rifling.—The rifling is polygroove and parabolic in development. The number of grooves is equal to twice the caliber of gun, expressed in centimeters.

Rotating Rings.—A single rotating ring of copper is used for all calibers. Its exact position has been determined by extensive series of experiments.

Wire Construction.—The exponent of the system of wire-wrapping for cannon in France is the Schultz gun. A 34-centimetre gun made on the plan of Captain Schultz was built up as follows: A steel tube was wrapped circumferentially with steel wire and inclosed in a wrought-iron jacket; the longitudinal strain and the effort to blow out the breech was resisted by twelve longitudinal bars of steel set up at as equal a tension as possible between two bands shrunk on over the jacket, the forward carrying the trunnions and the rear inclosing the breech mechanism. The gun was made at the works of the Compagnie de Fives-Lille, under the supervision of Captain Schultz, and was sent to Gâvre to be fired. Owing to the unequal tension of the longitudinal bars the gun failed at the first fire. The cause of the failure can be thus distinctly asserted as the sound of the *successive* ruptures of the bars was recognized by those who assisted at the experiment.

Previous to its trial, and in anticipation of success, four cast-iron guns of 24 centimetres were sent to Fives-Lille to be converted on the same principle. They are tubed with steel as far as the trunnions, and are wrapped with wire. The longitudinal bars are yet to be adjusted, after which they will be subjected to trial, with but faint hopes of success, as the failure of the original gun seems to have indicated very positively the mechanical impossibility of securing an equal strain on the longitudinal bars. The contract, however, having been made for the conversion of the four guns above named, it will be carried on to its completion.

For future construction, however, the system of taking up the longitudinal effort with bars is abandoned, and the 34-centimetre gun now at Gâvre is to be returned to Fives-Lille for reconstruction. This will consist in replacing the bars with a jacket shrunk on over the wire wrappings, and which, at its forward end, will hook over the band already shrunk on the gun, and at its rear end be notched into the band containing the breech mechanism.

A gun of 10 centimetres built upon this system is now being experimented with at Gâvre, and the results have been sufficiently satisfactory to justify enlarging the chamber for the purpose of testing the gun with increased charges.

The above exhibits the present condition of this problem in France.

GERMANY.

Among the places that the Board desired to visit in Europe was included the famous establishment of Mr. Fried. Krupp, at Essen, in Westphalia; and, as in all cases where it was proposed to visit private works, a letter was addressed to Mr. Krupp, through his agent in London, requesting the necessary permission.

The permission was refused. The correspondence relating to this subject will be found in the files attached to the record of proceedings and in Appendices O, P, Q, R, S, T, U, V, of this report.

From the above statement it will be seen that the Board is unable to submit any information founded upon personal observation. For the general purposes, however, of this report the following statements will be appropriate:

With the exception of the small gun factory at Spandau, near Berlin, where a limited number of cannon up to 15 centimetres and some rifled mortars are fabricated, the source from which the armaments of Germany are supplied is the establishment of Mr. Fried. Krupp. The Government has no control over the works, consequently the principal dependence is on this private company. Owing to the great enterprise exhibited in the management, and to the support of the Government, the establishment has, for many years, enjoyed a monopoly of the manufacture of cannon for Germany and it has been enabled to furnish guns to many other powers, notably to Russia.

As to the condition of the steel manufacture as relates to cannon, it is known that it was the practice to cast gun ingots exclusively of steel prepared in crucibles; ingots of the weight of 80 tons have been cast from crucibles more than 12 years ago. The Board is not able to state whether gun ingots are now cast exclusively from crucibles or whether they are now made from open-hearth furnaces.

The following is the present condition of the German artillery, taken from official sources:

	Calibers.
8-centimetre pivot-cannon	
8.4-centimetre-field-gun	25.6
8.7-centimetre	50
10.5-centimetre	
10.5-centimetre	35
10.7-centimetre pivot-cannon	
12-centimetre, navy and coast, light	25
12-centimetre	30
15-centimetre pivot-cannon	
15-centimetre siege-gun	
15-centimetre, navy and coast	25
15-centimetre	30
15-centimetre, navy and coast	35
21-centimetre	30
21-centimetre mortar	
24-centimetre, 19 tons	30
24-centimetre, 21 tons	35
26-centimetre	35
28-centimetre	35
30.5-centimetre, light, 32 tons	25
30.5-centimetre, heavy	25
30.5-centimetre, 43 tons	30
30.5-centimetre, navy and coast, 48 tons	35
35.5-centimetre, 51 tons	25
35.5-centimetre, 68 tons	30
35.5-centimetre, 76 tons	35
40-centimetre, 72 tons	25
40-centimetre, 97 tons	30
40-centimetre, 109 tons	35

The power of the Krupp gun is best illustrated by the reports of firings that took place at Meppen in 1879 and subsequently. These reports are available for reference.

The material used in the construction of the Krupp guns is steel.

The system of construction is that of a built-up gun, with tube and hoops. In the larger guns of latest design the first hoop shrunk on the rear of the tube is lengthened, resembling the jacket of the Vavasseur design.

The fermeture is the cylindro-prismatic wedge, modified from the original invention of Mr. Broadwell, and adopted by Mr. Krupp. The gas-check is also the invention of Mr. Broadwell and bears his name.

The Board can give no information upon the subject of wire-construction in Germany.

The essential point to be observed in this short notice is that the main supply of the artillery of Germany is drawn from one private firm. In this respect the method differs from that followed either in England or in France. It goes without saying that the Government pays a high price for the manufactured article.

RUSSIA.

SOURCES FROM WHICH THE ARMAMENT OF RUSSIA IS SUPPLIED.

The Government of Russia has been an extensive purchaser of cannon from Mr. Krupp, at Essen; but, after adopting the Krupp gun for its armament, it proceeded to manufacture on that system for its own uses.

The course pursued to produce a supply from home manufacture was that of joint action between the Government and a private firm. The large steel works of Aboukhoff, near St. Petersburg, was the establishment with which the Government entered into partnership, becoming the owner of one-third of the stock. The Government is represented in the board of directors, the works are in the hands of the Minister of Marine and Admiral Kolokoltzoff is the chief administrator or superintendent. At the commencement of the joint action, the Government contributed largely to increase the plant by providing tools suitable for its work, and very substantial aid has been provided from time to time.

The substance of this statement was collected from parties with whom intercourse was held, who did not, in distinct words, condemn the practice under which the Government has been acting since it commenced to manufacture its own guns, but they evidently held the idea that the condition of affairs would be much improved if the Government had absolute control of the works. In order to achieve this object it was understood that the Government is soon to acquire such additional stock as will make it owner of about two-thirds of the whole. When this shall be accomplished it is thought that the Government will be able to produce its guns at less expense than is now incurred.

It was freely admitted that the material produced under this system of joint action has been at great cost, but the Government has reconciled itself by the conviction that the product was of first-class quality and better than could be procured from other sources at less expense. The ground is taken that, in a matter so important as armament, high price is not to be considered an obstacle to the possession of the best guns

that can be produced, and the authorities believe they have attained this object in their manufacture.

This experience of the Russian Government in its joint action with the Aboukhoff Steel Works bears directly upon one of the most important points that the Board is required to consider, viz, "any other method" apart from a Government foundry, pure and simple, by which cannon can be provided; and the results above cited demonstrate that in this combination in Russia, as in that between the English Government and the Elswick Ordnance Company, the Government must always expect to bear the loss.

The acquisition of additional stock may give the Government such control in the direction of the business of the works as to smooth the way to its possession of the whole. This seems to be the natural conclusion of the process now in operation, and its consummation would be a declaration of the practical failure of the plan inaugurated at the commencement. The experience of joint action between the Government and a private firm in Russia does not encourage the experiment in our own country.

Nearly the entire production of steel for cannon is distributed between the Aboukhoff Steel Works and the Kama, near Perm (in the Ural Mountains), but the product of the former is the more considerable. Among others, the Iznoskof and Alexandroff private steel works (both near St. Petersburg) manufacture projectiles, and as the Government diminishes its contracts abroad they will develop their plants to meet the demands for gun material.

Russian Artillery-Gun Factory.—Although the amount of field artillery and siege pieces in the possession of the Government is very large the work of manufacture is actively progressing, and the Russian Artillery Gun-Factory in St. Petersburg is constantly occupied in the construction of guns up to and including the 8-inch, and rifled mortars of 9-inch caliber. This factory is well supplied with tools, has a capacity to turn out 70 field guns per month and is rapidly replacing the older models on hand; but its plant is not equal to all the work demanded of it. The deficiencies are supplemented by the Aboukhoff Works.

Aboukhoff Works.—The Aboukhoff Works, which include the manufacture of steel on a large scale and the fabrication of cannon of all calibers, both for the army and the navy, are situated in the alluvial basin of the Neva River, where good foundations are to be had only at great expense. The excavation for the 50-ton hammer was carried down 50 feet before moderately hard bottom (gravel) was reached. This cause has added largely to the general cost of construction of the works.

The shops are extensive and numerous, but as they have been erected as needed, without regard to any general plan, they furnish no guide for constructing a new establishment. The largest gun shop is 700 feet long and 70 feet wide, with the tools disposed longitudinally. The severity of the climate has rendered it necessary to seal overhead with wood, and from this cause the shop is not so well lighted as is usual in Europe. The plant is of good quality and is being extensively developed. In the foundry advantage has been taken of the undulations of the ground to place the forge at a lower level than the furnaces, thus conveniently providing for the transportation of the hot ingots by railway direct from the bottom of the casting pit to the hammers. The capacity for casting reaches from 40 to 50 tons, requiring 1,200 crucibles.

CONDITION OF STEEL MANUFACTURE.

There can be no question as to the character of the ore from which the metal used for cannon in Russia is produced. The Russian mines, from which much of it is obtained, are situated in the Ural Mountains on the border of Siberia. The ore is smelted with charcoal, and the iron is fully equal to the famed iron of Sweden. It is received at the Aboukhoff Works in the form of cast and wrought iron. Use is also made of the best Swedish and Spanish iron.

The puddled steel, which is the basis of the Russian gun-metal, is prepared at Perm and at the Aboukhoff Works. The steel for casting all gun tubes, jackets and large hoops, is prepared in crucibles. A portion of the magnetic ore, which is found in the Ural, is one of the elements introduced into the crucibles and is said to have a beneficial effect upon the mixture.

Hoops for some small guns are made of Bessemer steel, the charge being selected from the best Ural and Swedish ores. The Siemens-Martin Process is restricted to the manufacture of small ingots, being regarded with much less favor than crucible castings.

The most important improvement which has recently been introduced is Sir Joseph Whitworth's system of liquid compression. The advantages of this press have been alluded to in a former part of this report and need not be again recited. At the Aboukhoff Works, the effect of liquid compression is considered as very beneficial, and the impression was received that the system of forging by the press would also have been adopted if there had not already been established at the works one of the largest and most expensive hammers in the world, the tup of which weighs 50 tons, with a fall of 12 feet.

PRESENT CONDITION OF RUSSIAN ARTILLERY.

Russia has adopted the Krupp breech-loading system with slight modifications for all calibers, but a few guns fitted with the French interrupted screw were noted. Steel alone is used for new fabrications.

The heavy ordnance for naval and sea-coast defense is designed to give velocities from 1,700 to 1,800 feet; but experiments to gain an increase, by lengthening the bore, are in progress. The following are the principal calibers:

12-inch 40-ton guns, 20 calibers long, are adapted for arming the "Peter the Great" and the "Popoff"—one, 30 calibers in length, weighing 50 tons, and burning 390 pounds of powder, is now under trial.

11-inch 27-ton guns, 22 calibers long, are used in several turret ships and in sea-coast batteries. The tube requires a 30-ton ingot.

There are also many naval 9-inch, 8 inch, and 6-inch guns about 22 calibers long, in service; but the models will soon be modified by increasing the length. For land fortresses the 6-inch gun is the prevailing type. Most siege guns on hand are of bronze, but a new steel pattern will be adopted for future fabrication.

A recent accident gave a severe test to the system of construction adopted for Russian artillery. In experimenting with gun-cotton for use in shells, one of the latter, containing 40 pounds, exploded in the chamber of an 11-inch gun when the charge of gunpowder (128 pounds) was fired. The rear part of the breech was blown off at the weak point of the Krupp system. The trunnion-band was broken, throwing off a fragment; and *the diameter of the chamber was enlarged* 1 *inch*. The

admirable quality of the metal, and the good adjustment of the strength of the several parts is evident from this statement.

In testing steel no value is attached to the ultimate breaking stress or percentage of elongation; and the computations are all based on the elastic limit which is determined by noting where the increasing stresses and elongations cease to be proportional. This must never occur below 2,400 atmospheres (16 tons per square inch).

Construction.—All field guns are of steel, and are mounted on a carriage fitted with rubber buffers to reduce the shock.

The special novelty of the Russian ordnance is a thin steel lining tube, designed to receive the wear in firing and to be renewed when needful, without the expense and difficulty of re tubing. This system is adopted for all calibers from the smallest up to the 12-inch gun, inclusive. The operation of inserting one of these lining tubes in a field gun was witnessed at Aboukhoff. The difference of their diameters was very small. The fitting of the slightly conical surfaces by measurement before insertion was done with precision.

When ready for insertion the lining tube was lubricated and introduced by hand. It was forced by hand levers until the end was nearly flush with the breech; hydraulic power then applied by a hand-pump was gradually increased to a pressure of 180 atmospheres, although no motion was apparent after it had reached 100 atmospheres. The rear end of the lining tube forms the recess for the Broadwell ring.

The Russian officers claim that these tubes can be renewed in the field, and cited instances of two 9-inch mortars, weighing 5½ tons each, needed for use on the Danube during the late war. Being too heavy for the available means of transportation they were forwarded in three pieces—a tube, a breech-jacket and a muzzle-jacket. The two latter were screwed together, and the tube was inserted by a jack on the spot; both mortars did excellent service.

Sheets of recent unpublished experiments were exhibited, showing the locus of the varying pressure in the bore of a long 4.2-inch gun. These pressures were measured by Rodman gauges in the usual way, special care being taken to place the part acted upon by the gas nearly flush with the bore. The results thus far have proved quite accordant and very interesting, indicating that as the distance from the bottom of the bore increases the pressures at first decrease a little, and then rapidly increase to a maximum at a point slightly in rear of that originally occupied by the front band of the projectile. Here the pressure is nearly double that at the bottom of the bore, and evidently is increased by the reaction from the shot at the instant of taking the grooves. This investigation has much importance in connection with the problem of the best form and dimensions for the powder chamber. The experiments are to be continued with a 16-inch 80-ton steel gun made at Aboukhoff and fitted for this purpose. It is 22 calibers long and constructed in the following manner, viz.: tube in one piece; jacket in three parts extending to muzzle; four layers of hoops and a fifth hoop over the breech. It is pierced at various points to receive the gauges.

An experimental 11-inch 47-ton all-steel gun, 35 calibers long, consisting of tube, jacket in two parts extending to muzzle, and three layers of tapering hoops, was ready for trial.

Rotating Rings.—Projectiles are fitted with two copper bands, the front one to give a uniform bearing and the rear to take the rifling. Both are made of rods hammered into place by hand, because this is supposed to give a better hold than can be had by machinery.

The experiments with Russian artillery are made at the Polygon at

Ochta, near St. Petersburg. The grounds afford a range of about 7 miles, and the establishment of the navy, under Admiral Kouprianoff, and of the army, under General Erme, are side by side, so that each service can always witness what is done by the other. A 12-inch 50-ton rifle, an 11-inch and several smaller guns were in position at our visit.

THE UNITED STATES.

SOURCES FROM WHICH THE ARMANENT OF THE UNITED STATES IS SUPPLIED.

Previous to and during the civil war the armaments of the United States were supplied from—

The Cold Spring Foundry, West Point, N. Y.
The South Boston Iron Works, Boston, Mass.
The Fort Pitt Foundry, Pittsburgh, Pa.
The Reading Iron Works, Reading, Pa.
The Builders' Iron Foundry, Providence, R. I.
The Phœnix Iron Company, Phœnixville, Pa.
The Ames Manufacturing Company, Chicopee, Mass.

Since the termination of the war the Fort Pitt Foundry has ceased to exist. The South Boston Iron Works Company has manufactured a few experimental guns, and with the West Point Foundry has executed some small orders of the Government in the conversion of cast-iron smooth-bores into rifle guns by inserting and rifling a coiled wrought iron tube.

None of the companies mentioned above have ever made steel guns, and virtually the United States is destitute of a source from which such an armament as the age demands can be supplied.

CONDITION OF STEEL MANUFACTURE.

With a view to such experiments as their appropriations would justify, the Ordnance Bureaus of the War and Navy Departments have from time to time addressed the steel manufacturers of the country on the subject of furnishing steel for cannon, but thus far have met with only a partial success.

The reasons for this will be noticed farther on in this report, but the fact is here stated to emphasize the conclusion that the immense steel works of the United States, from lack of demand for this special material, have not the necessary plant for forging, and are in no condition at present to manufacture steel for cannon in such quantities and in such sizes as are essential for a suitable armament for the country.

PRESENT CONDITION OF THE ARTILLERY OF THE UNITED STATES.

To recite under this heading the present armament of the country is unnecessary. Before the introduction of rifled cannon and the use of steel as the material for their construction, the United States boasted of her Dahlgren and Rodman cast-iron guns, which were the models for imitation and the standards for comparison of all nations.

While the rest of the world has advanced with the progress of the age, the artillery of the United States has made no step forwards. Its present condition of inferiority is only the natural result of such want of action.

COST OF PLANT FOR THE MANUFACTURE OF GUNS.

From information gained in its investigations and from consultation with the managers of those large establishments abroad where gun tools are made, the Board submits the following estimates.

As it will recommend that "for the manufacture of heavy ordnance adapted to modern warfare," the steel should be produced by private companies and the guns fabricated in Government shops, these estimates will be made under three heads, viz:

Machines and tools for steel plant.
Machines and tools for gun factory.
Buildings.

MACHINES AND TOOLS FOR STEEL PLANT.

On the matter of plant for casting and forging the Board obtained information chiefly from Sir Joseph Whitworth & Co., of Manchester, and from Messrs. Tannett, Walker & Co., of Leeds, England.

The following is an approximate cost of plant for casting and forging ingots up to 100 tons, submited by Tannett, Walker & Co.:

Sixteen groups (4 each) gas producers.
Ten 12-ton Siemens furnaces.
Two large reheating furnaces.
Five 24-ton hydraulic center-casting cranes.
Six 5-ton ingot cranes.
Two 170-ton and two 30-ton power traveling cranes, 50 feet span, with engines.
Two 24 feet by 19 feet hydraulic accumulators.
Two pairs pumping engines; either 18 inches by 24 inches (single), or 15 inches by 28 inches by 24 inches (compound).
One overhead tank.
Pipes for above hydraulic cranes.
One 3,000-ton hydraulic press.
One pair pumping engines for working press.
Total cost, exclusive of buildings, about $300,000.

This estimate does not include tools for rough boring or turning, nor appliances for tempering.

The additional cost of these tools and appliances should be added as forming part of the expenses properly belonging to the foundry. As will appear hereafter, the cost of a complete plant for rough boring and turning, including all guns up to 100 tons, will be about $210,000; the tempering pit, furnaces, &c., will cost about $50,000; which, exclusive of buildings, would, upon the estimate of Tannett, Walker & Co., make the total cost of a plant capable of casting, forging, rough boring, rough turning and tempering the parts of guns up to 100 tons, about $560,000.

The following is an estimate from another source, for a 100-ton ingot steel plant, confined exclusively to the process of casting:

Eight 15-ton Siemens furnaces, with platform and producers complete.
Two ordinary travelers for ingot-pit.
Eight 15-ton ladles.
Railway metal and laying.
Hydraulic cranes.
Cost, exclusive of buildings, about $215,000.

The following is an approximate price of a plant for casting and forging 72-ton ingots:

Ten groups (4 each) gas producers.
Six 12-ton Siemens furnaces.
Two large reheating furnaces.
Three 24-ton hydraulic center-casting cranes.

Pipes for hydraulic cranes.
Four 5-ton ingot cranes.
Two 100-ton and two 30-ton power traveling cranes, 50 feet span, with engines.
Two 18-feet by 19 feet hydraulic accumulators.
Two pairs pumping engines, either 18 inches by 24 inches (single), or 15 inches by 28 inches by 24 inches (compound).
One overhead tank.
One 3,000-ton hydraulic press.
One pair pumping engines for working press.
Cost, exclusive of buildings, about $205,000.

The following is an estimate submitted by Sir Joseph Whitworth for a plant for casting 60-ton ingots:

Three 20-ton melting furnaces, including all steel and iron work, all silica and fire-bricks, valves, levers, stages, ladles, apparatus for making clay used in the moulds and ladles, the iron work and all fire-bricks for gas producers, a competent man to superintend erection, but exclusive of all common bricks, brick-setting, excavating, &c., $70,000.

This plant, if supplied with a sufficient number of re-heating furnaces and kept in full work, would be capable of turning out 150 to 200 tons of large gun material per week.

The following are estimates submitted by Sir Joseph Whitworth for forging presses:

A 34-inch hydraulic forging press, complete with its engines, pumps, boilers, two hydraulic traveling cranes, two re-heating furnaces with hydraulic apparatus for raising the doors. An assortment of steel chucks, mandrels, draw-bars, porter-bars, swage and other blocks for enlarging and reducing hoops, &c., apparatus for withdrawing mandrels, &c., $200,000.
A 24-inch hydraulic forging press, complete in all details, as in the case of the large one already cited, will cost about $140,000.

The forging press, though not a new idea, has been but little used; in fact, to this time, it has been adopted in but one large establishment in the world; consequently its manufacture is costly. Its general adoption is now a matter of certainty, and its cost will no doubt be reduced; hence, it is probable that a 36-inch forging press with cranes, engines, pumps, accumulators, &c., exclusive of buildings, may be obtained for $150,000.

If the system of liquid compression should be adopted, the additional cost of a hydraulic casting press, complete, including steel mould boxes, overhead hydraulic traveling cranes to lift 100 tons, including columns and girders, and complete in every respect, except masonry and brick-work, would be $175,000.

The following is an estimate of the cost of tools for rough boring and turning the parts of guns for all calibers up to 16 inches:

One rough-turning lathe for tubes and jackets up to 12-inch caliber.
Three rough-boring lathes for same.
One rough-turning lathe for tubes and jackets up to 16-inch caliber.
Two rough-boring lathes for same.
One 100-ton power traveling crane.
One 20-ton power traveling crane.

Tools for the above, including:

Assorted tools for rough-turning lathes.
Forged cast-steel boring bars with head and steel cutters for boring tubes out of the solid.
Forged cast-steel bars for boring jackets.
Sets of tools for each of the hoop and trunnion lathes, and for the slotting machines.
The total cost will be about $210,000.

If a complete set of trepanning tools were to be furnished for the work of rough boring, the additional cost will be about $50,000. The first cost of these tools is very great, as they are made from very large

ingots of cast steel, oil tempered, which have to be bored and turned almost entirely away.

The above estimates respond to the call of the act of Congress so far as relates to cost of a steel plant for the manufacture of the heaviest guns, and will answer some of the inquiries of, and serve as a guide for, those of our steel manufacturers who shall undertake to supply the Government with the required material for modern artillery.

As the greater includes the less, it may be taken for granted that no plant for smaller work can equal the above estimate. The scale of diminution in proportion to the weight of metal and capacity of cranes, presses, &c., may be approximated, and the following list of weight of forgings required for different calibers in the English service will assist the calculation:

Particulars of forgings for English gun tubes.

Weight and caliber of gun.	Weight of ingot cast.	Weight of forging for tube.	Model.
110 tons	About 100 tons	70 tons	New.
100 tons, 17 inches	{ Breech part, 27 tons { Muzzle part, 15 tons	{ 21 tons, 2 cwt. { 12 tons, 11½ cwt.	Old.
80 tons, 16 inches	21 tons	17 tons, 7 cwt.	Old.
63 tons, 13.5 inches	35 tons	27 tons, 17 cwt.	New.
43 tons, 12 inches	27 tons	21 tons	New.
26 tons, 10.2 inches	14 tons	11 tons, 10 cwt.	New.
18 tons, 9.2 inches	12½ tons	10 tons, 5 cwt.	New.
11½ tons, 8 inches	10½ tons	8 tons	New.
80 cwt., 6 inches	4½ tons	3 tons, 12½ cwt.	.....
38 cwt., 50-pounder	2½ tons	1 ton, 18½ cwt.	.....
22 cwt., 4-pounder	1½ ton	1 ton, 2½ cwt.	.....

The forging for the 100-ton gun cited above is that which was supplied for the Armstrong gun furnished the Italian Government, the tube for which was made in two parts. That for the 110-ton gun now to be made for the English Government will be in one forging.

If the cost per ton be fixed for the smaller guns, and an increasing ratio be established per ton as the caliber increases, the approximate cost of the forgings for guns of like pattern can be determined.

From an inspection of the table given above it will be seen that it is within the resources of many of our own steel works to supply castings for a large number of the different calibers. These works, however, are deficient in forging apparatus.

In the above estimates the cost of a steam hammer is not given, as the Board unanimously approves the adoption of the press; but it will be pertinent to add that, in order to produce a given amount of work, the hammer is the more expensive tool.

MACHINES AND TOOLS FOR GUN FACTORY.

On the matter of plant for gun factory the Board obtained information from the principal gun facories of England, France and Russia, where machines and tools are in operation, and from the largest establishments where such tools are made, but chiefly from Messrs. Greenwood & Batley, of Leeds, Mr. Hulze & Co., of Manchester, and Messrs. Varrell, Elwell & Middleton, of Paris.

In considering this part of the subject it was decided that there were three classes into which guns could be advantageously divided in reference to tools suitable for their fabrication, viz:

(I.) Guns of 6-inch and all below that caliber.

(II.) Guns from 6-inch to 12-inch caliber.

(III.) Guns of caliber greater than 12 inches.

It was necessary to adopt a tool as a unit on which to base the calculation that should determine the number of tools required under the above classes. The rifling machine was the unit adopted. The object was to so proportion the numbers of each tool as to keep the rifling machine constantly employed.

In the solution of this problem the Board has had the advantage of the able assistance of the firm of Greenwood & Batley, of Leeds, England, whose tools were seen in all the large gun factories visited in Europe. They have spent much time and incurred much expense in providing plans and estimates and have communicated most valuable confidential information. The following estimates, stated in a general way, are the results, and the Board is confident of the essential accuracy.

(I.) Cost of Gun Factory Plant up to 6-inch Caliber.

This plant does not include rough boring and turning lathes for tubes, jackets, and hoops; these parts are supposed to be supplied ready for finishing. It includes:

Two finish turning lathes.
Three finish boring lathes.
One lathe to chamber, cut breech-screws, &c.
One rifling machine.
One milling and drilling machine.
One 10-ton power traveling crane.
Tools for above, including—
A set of turning tools for each finish turning lathe.
One boring bar with head and cast-steel tools for boring lathes.
One chambering bar with cutting tools.
One steel bar and cutting tools for screw-cutting and shaping out spaces.
One hollow rifling bar with cutter, adjustment, and cutting tools.
Milling cutters and mortice drills for milling and drilling machines.
The total cost will be about $50,000.

This plant is capable of producing one 6-inch gun per week, or a proportionally larger number of smaller calibers.

(II.) Cost of Gun Factory Plant up to 12-inch Caliber.

This plant does not include rough boring and turning; the parts are supposed to be supplied ready for finishing. It includes:

One finish turning lathe.
Three finish boring, turning, and chambering lathes.
One machine to cut breech-screw, &c.
One rifling machine.
One milling and drilling machine.
Four combined boring and turning face lathes for hoops.
One combined boring and turning face lathe for trunnion hoops.
One combined boring and turning lathe for trunnions.
One slotting machine for trunnion hoops.
One 40-ton power traveling crane.
Tools for the above, including—
Cast-iron tubes with steel head and cutter for finish boring tubes.
Cast-iron tube with steel head and cutters for finish boring jackets.
One chambering bar.
Fifty assorted turning tools for finish turning lathes and machine for cutting breech screw and spaces.
Cast-iron hollow rifling bar with cutter head, adjustments, steel tube for actuating tool, and cutting tools.
Four milling cutters and mortise drills for milling and drilling machine.
The total cost will be about $150,000.

This plant is capable of producing one 12-inch gun every three weeks, or a proportionally larger number of smaller calibers.

(III.)—Cost of Gun Factory Plant up to 16-inch Caliber.

This plant does not include rough-boring and turning; the parts are supposed to be supplied ready for finishing. It includes:

Two finish turning lathes.
Three finish boring, turning, and chambering lathes.
One machine to cut breech-screw, &c.
One rifling machine.
One milling and drilling machine.
Four combined boring and turning face lathes for hoops.
Four combined boring and turning face lathes for trunnion hoops.
One combined boring and turning lathe for trunnions.
One slotting machine for trunnion hoops.
One 100-ton power traveling crane.
Tools for the above, including—
Two cast-iron tubes with steel boring head and cutters for finish boring tubes.
One cast-iron tube with steel boring head and cutters for finish boring jackets.
One steel chambering bar.
Fifty assorted turning tools for finish turning lathes and machine for cutting breech-screw and spaces.
One cast-iron hollow rifling bar with cutter head, adjustments, steel tube for actuating tool, and cutting tools.
Four milling cutters and mortise drills for the milling and drilling machines.
The total cost will be about $350,000.

This plant will produce one 16-inch gun per month, or a proportionally larger number of smaller calibers. In the room allotted to shrinking on the jackets and hoops, there will be required an additional traveling crane capable of handling guns of the heaviest weight, which will cost about $17,500.

From these estimates, the cost of equipping a gun factory capable of producing guns from the lowest caliber up to 16 inches, will be about $570,000.

If the tools mentioned above are to be made in the United States, these estimates would have to be largely increased, because there has been no demand to especially direct the attention of our manufacturers to them; from this want of experience great delay and expense would result in the preparation of plans, specifications and patterns.

A wise policy would seem to demand that the tools required in this first plant should be purchased from those parties abroad who have had the most valuable experience in their manufacture.

Buildings.—At most of the establishments visited by the Board, the buildings have been constructed successively to meet increasing demands for space; and they therefore do not exhibit that systematic study which naturally would be demanded in planning a new gun factory. In such a problem the first step would be to decide upon the tools to be ordered, and their most convenient arrangement, and then the architect would be able to design the most suitable buildings.

As the Board will recommend that the manufacture of the metal and the fabrication of the guns shall be separately considered, and that the work shall be done at different localities, it has regarded the proposition of detailed plans for the buildings as inexpedient, not only because there would be little probability of their final adoption, but also because the time required for the estimates would materially delay the completion of the report. The subject, therefore, will be treated in a general manner. The following are the most important points developed by experience in Europe:

1st. Substantial foundations.

2d. Strong, but economical, superstructures secure against destruction by fire.

3d. Carefully considered lighting arrangements.

4th. Dimensions suited to the most convenient use of the tools, but which avoid waste space under cover.

Two distinct arrangements are in use abroad. In one, best illustrated by the new shops of Sir Joseph Whitworth, at Manchester (intended for general work), all the operations are performed under a single roof, a plan which has the merit of bringing all the workmen under the eye of the superintendent. The building has ten bays, each 50 feet wide, and at present 575 feet long, but it is proposed to extend this length 200 feet. Six bays are devoted to the foundry proper where the steel is manufactured and forged, and the remaining four to the tools used in fabricating the finished products. A gallery 25 feet wide extends along one side of the building forming a second story where small tools are made. Overhead cranes are provided, where necessary, to run the whole length of a bay, and the larger machines are disposed longitudinally under them. The height of the run-ways of these cranes is 22½ feet above the floor. Each bay is covered by a roof of 50 feet span and 18 feet rise. These roofs unite in valleys 8½ feet above the run-ways, to afford room for the cranes; and light is supplied by continuous windows, which, on the south side form the middle third, and on the north side the two-thirds of the roofs. The outer walls are brick. The bays are separated by rows of cast-iron columns capped with wrought-iron trusses, on which rest the iron roofs.

These magnificent shops, constructed very recently, after Sir Joseph's long experience in such work, cost per running 50 feet of each bay:

Iron work of supports	$1,250
Roof plating, glazing, glass, lead, &c	2,000
Floors, plates, &c	1,190
Contingencies	560
Total per square 50 feet, about	5,000

Estimated upon this basis, given by one of the engineers, the total cost must have been at least $600,000.

In the other general arrangement of shops which prevailed at most of the establishments visited, different buildings are provided for different classes of work, with ample space between them for railway tracks, storage of metal, &c. Experience seems to have suggested the importance of the following points:

The run-ways of the large cranes should be supported quite independently of the buildings. As their spans vary from 40 to 64 feet, generally about 50 feet, this is an important matter. There is no economy in constructing the walls to bear strains thrown upon them by powerful machinery. The true function of the building is simply to cover the tools against the weather.

The problem of reducing the cost of roof trusses is an important one. For smaller machines, an economical and convenient arrangement was noted at the army establishment at Bourges. The building was about 260 feet long and 150 feet wide. Advantage was taken of the lesser height required for this class of work to dispense with roof trusses entirely. Cast-iron columns, about 17 or 18 feet apart, divided the whole interior into squares and furnished supports for the roof at so many points as to effect this object. The tools were disposed across the shop, and hand cranes overhead and medial railway tracks for cars supplied every facility for convenient handling. For the larger tools, however, the spans are necessarily so great that it seems expedient to increase their width so as to dispose the machines across the bays. This

enables the arrangements to be very compact and enough is saved in length of shop to compensate for wide trusses. Thus, in the two new shops at Ruelle, which are good models, the span of the principal roof trusses are about 50 feet and 82 feet respectively, the total width of the buildings being extended by parallel and lower roofs to 98 feet and 130 feet.

Roof-lighting of gun-shops is general throughout Europe. Sometimes, as in Sir Joseph Whitworth's establishment, the ridge-pole is placed centrally between bearings, and one-third of the south and two-thirds of the north surface is glazed. At other places, as at the shop at Bourges just described, the ridge-pole is nearer the north side, and the short and steep side of the roof only is glazed. Another plan is the common device of a ventilator cap over the ridge-pole, with vertical lighting. As a rule all available space at the sides and ends of the buildings are given up to windows. No gun-shops of more than one story were noted.

The Board would recommend the erection of fire-proof structures of a single story, designed solely to cover and protect the tools. Their style of architecture should be neat, but not extravagant; convenience of arrangements and facilities for lighting should receive careful study. It is believed that the cost of such buildings as are required can be safely estimated at $5,000 per square of 50 feet.

GENERAL SUMMARY.

The foregoing presents the chief points of information that have been gained by the investigations of the Board.

As examples of a practical partnership between a Government and a private company in working towards anational object the experiences in England and in Russia are very instructive, and warn against the adoption of such a system. In England, the Government, in addition to paying, during several years, very high prices for articles delivered, was forced to pay £65,000 to close an agreement; while the company, besides the profits on manufacture, came into possession of a complete working plant at a mere nominal valuation.

In Russia the Government finds itself involved with a stock company, paying excessive prices for what it receives, and discovers no way of relief. except by buying up shares and operating the establishment as a Government foundry.

As an example of depending almost entirely on private works Germany is a perfect instance. The works of Mr. Krupp are practically the sole source of supply of the German artillery. In such a case the Government must be the slave of the corporation, and subject to its whims, caprices, and conveniences. It needs no argument to show the dependent condition of the Government under such a rule; it might prove a source of the greatest embarrassment. The Board is well informed that some ten or eleven years ago the artillery officers were very restive under this load and were making strenuous efforts to be relieved from it, but without success. It is hardly to be supposed that time has quieted the feeling of dissatisfaction.

As an example of depending alone on Government works France was a perfect instance before the Franco-German war. During the period referred to the Government foundries were the sole source of supply of the armament of the country; the officers charged with the work formed a close corporation; their action was never exposed to the public; their ideas were

never subjected to criticism; the ingenuity and inventive talent of the country were ignored and resisted, and no precaution was thought necessary to provide a supply in case of need of re-armament. The result is well known; a great crisis came; the Government works were inadequate to meet the additional demands made upon them, and the patriotic efforts of private establishments were inadequate to produce all the material that was needed. How entirely France has now altered her system is shown in a previous part of this report; her present practice is theoretically perfect, and it has proved to be practically efficient. Her Government establishments are still retained, but as gun *factories* simply, in which the parts are machined and assembled, but for *foundry* work she depends upon the private industries of the country, and many of these works have found it to their profit to establish gun factories which supplement the Government factories to a great extent.

The conclusions of the Board on this subject accord with the plain teachings of these historical instances. It accepts the system now pursued in France as the proper standard for imitation, and recommends that in inaugurating the manufacture of war material in our own country a conformity as close as circumstances will admit to the plans which have proved so successful in France should be observed.

Having reached this conclusion, the Board is now prepared to dispose of the propositions into which, as stated on the seventh page of this report, the second interrogatory in the act of Congress was divided. The first proposition was thus presented, viz:

> That the Government should supplement the plants of some of the steel workers of the country with such additional tools and implements as would enable them to turn out finished steel cannon.

The adoption of this proposition would involve the Government in the embarrassments which now exist in Russia, and which we have seen were so costly to the English Government in its partnership with the Elswick Ordnance Company.

The Board does not approve of such joint action.

The second proposition was thus presented, viz:

> That the Government should give contracts of sufficient magnitude to enable the steel workers of the country to supply the finished guns without its direct aid.

This proposition, if adopted without any qualification, would make the Government dependent entirely upon the private industries of the country, which might combine to the detriment of the public service. The Government would have no guard against extortion and would be powerless against a combination. An actual instance of such a combination is cited in a previous portion of this report as having taken place in France, but the independent position of the Government made the effort futile.

The Board does not approve of this proposition taken by itself.

The third proposition was thus presented, viz:

> That the Government should establish on its own territory a plant for the fabrication of cannon, and should contract with private parties to such amounts as would enable them to supply from the private industries of the country the forged and tempered material.

This proposition is approved by the Board and is regarded as the foundation upon which our system of manufacture should be built up. If this be done, and the Government made secure by the possession of works of its own, there is every reason to adopt in addition the idea embodied in the second proposition in order to *supplement* the Government establishments.

A state, with any pretensions to military power, should provide itself with factory facilities on a sufficient scale to perform the work of establishing standards, making experimental guns and fabricating cannon on a moderate scale; but it is not considered judicious to concentrate in the Government establishments all the work of fabrication or to include within their operations the preparation of such material as can be provided by the private industries of the country. In the case under consideration the purchase of the steel required for cannon will stimulate our own manufacturers and interest them in the operations of the Government.

The Board is thus led to the conclusion that it is not advisable to embark in the establishment of a gun *foundry*, properly so called, but that it is more judicious to establish gun *factories*, and to purchase the material from our manufacturers.

At present the steel manufacturers of our country are not prepared to produce the material required for the larger calibers, and the important question arises, what means shall be adopted to induce them to study the subject and embark in the manufacture on a large scale. They cannot be expected to do this at a sacrifice of their own interests. This object can only be achieved by holding out a fair prospect of ultimate remuneration for the expenditures necessary to undertake the work, and this can only be done by the action of Congress.

If, then, Congress shall conclude to arm the country it will be necessary that a sum of money shall be fixed as a permanent yearly appropriation to be expended for this purpose, the amount to be assigned proportionally between the War and Navy Departments. With such a guarantee against loss the Board is satisfied that the required material for cannon will be forthcoming from our own steel works.

It would not be necessary for the Government to be associated with a large number of firms for the supply of its material, for it is probable that the private establishments that would take up the subject would only be those with large available funds which they would be willing to put into a special plant, and for remuneration on which they would be willing to wait a reasonable time. The permanent appropriation would give them surety of ultimate profit, the only condition being success in providing the material that would be indicated in their contracts. From personal intercourse with some of the leading manufacturers the Board is led to believe that the plan will have the effect of guiding the private industries of the country to the aid of the Government in developing this work of national importance.*

It may be added that although the manufacture of armor plates for ships and fortifications was not referred to this Board for investigation, the erection of plant for providing modern cannon would go far towards reducing the outlay requisite to enable our great steel manufacturers to meet another pressing want of the Government.

The chief expense to be considered by private parties is that of the *forge*, but by the substitution of the hydraulic press for the hammer economy will be consulted and better results obtained. The Board is unanimous in approving the use of the press for all forging purposes; and recommends it to all who may embark in the manufacture of gun metal for the Government.

---

* This conclusion is fully sustained by letters, Appendices H, J, and by a communication received from the Cambria Iron Company on February 8, 1884, after the completion of this report. It is marked Appendix N.

In conclusion the Board submits its replies to the three interrogatories contained in the act of Congress:

(1.) Which of the navy-yards or arsenals owned by the Government has the best location, and is best adapted for the establishment of a Government foundry?

The Board does not recommend the establishment of a Government foundry, properly so called, which shall provide for the manufacture of steel and the fabrication of cannon. It considers that every inducement should be offered to attract the private industries of the country to the aid of the Government in providing ordnance for the Army and Navy, and that the steel manufacturers should be called upon to provide the material.

The Board recommends the establishment of two gun factories under the control of the Government and selects the—

Watervliet Arsenal, West Troy, N. Y., as the site for the Army, and the *Washington navy-yard, District of Columbia, as the site for the Navy.*

The Board is unanimous in recommending that the Army and the Navy should be provided with separate establishments. This has always been the custom in France, producing good results; the reverse has been the practice in England, producing bad results. Dissatisfaction from this cause has existed for many years in the English Navy, and the Admiralty has recently brought about a revolution in the system so far as the supply of gun-carriages is concerned, by obtaining from Parliament a separate and distinct appropriation with which it is providing the English Navy with the Vavasseur gun-carriage in opposition to the will of Woolwich.

In the administration of the War and Navy Departments of the United States, each service has charge and direction of its own distinct system of artillery, hence if but one gun factory be provided, its control must be placed in the hands of a mixed commission. This must lead to conflict of authority and to embarrassments of all kinds, in which the heads of Departments must necessarily become involved. A close scrutiny of the practical difficulties that would arise in conducting the affairs of a gun factory in such mixed interests develops obstacles that would be insuperable even with the most harmonious intent.

In the selection of the sites mentioned, it is not intended to convey the idea that they are regarded as in every way adapted for the purpose, but, as the scope for choice is limited, they are considered the most advantageous. The Board does not recommend the purchase of new sites, as this would open so wide a field for selection as to embarrass the question by arousing local interests throughout the country.

(2.) What other method if any (apart from the establishment of a Government foundry), should be adopted for the manufacture of heavy ordnance adapted to modern warfare, for the use of the Army and Navy of the United States.

With Government gun *factories* established for both the Army and the Navy, there will be still needed the hearty co-operation of the private industries of the country. This cannot be aroused unless there is held out to them a fair prospect of remuneration. The Board does not approve of a partnership in business between the Government and private firms. *All history warns against such a course.* But it does believe that joint, and at the same time independent, action between them can be made to work harmoniously towards the common national purpose. This can only be done by a permanent and liberal appropriation by Congress for the specific purpose of providing the country with modern artillery;

which appropriation shall be a guarantee against loss to the companies who elect to undertake the work.

This is entirely consistent with the action of Congress in providing for the supply of arms to the militia. The act authorizing this practice was passed in 1808 and since that time the yearly disbursement has been made from the Treasury without interruption. A similar act providing for the supply of heavy ordnance for the regular services will be but a farther development of the same idea.

(3.) The cost of all buildings, tools and implements, necessary to be used in the manufacture thereof, including the cost of a steam hammer or apparatus of sufficient size for the manufacture of the heaviest guns?

In reply to this question the Board presents an abstract of the information already given, arranged in a convenient form for reference.

Approximate cost of plant for producing the tempered parts of guns up to 100 tons, ready for delivery at gun factory:

Casting	$250,000
Forging (hydraulic press)	150,000
Rough boring and turning	210,000
Tempering	50,000
Total	660,000
Additional cost if liquid compression be adopted	175,000

Approximate cost of plant for gun factories:

Guns up to 6-inch caliber	50,000
Guns from 6-inch to 12-inch caliber	150,000
Guns from 12-inch to 16-inch caliber	350,000
Buildings and shrinking pit	350,000
Total	900,000

Three years will be required to complete the tools, construct the shops and establish the plant. Such a factory will be able to turn out per year fifty 6-inch, seventeen 12-inch and twelve 16-inch guns, or a proportionally larger number of smaller calibers, at a yearly expense of about $2,000,000. The figures cannot be pronounced exact, but the Board is confident that they closely approximate accuracy. The calculations are based upon estimates obtained abroad, and do not include ocean freight and customs dues.

Though the act of Congress replied to in the above report is one of inquiry, the Board desires to emphasize the necessity of a proper encouragement to the private steel manufacturers, which shall insure the supply of gun material without loss to the Government or private companies; and is of opinion if Congress shall be pleased to appropriate an adequate sum for providing modern artillery for the Army and Navy, to be held in the Treasury to be expended under the authority of the President, that (with such a prospect of remuneration) there are steel manufacturers in the United States who will undertake the production of gun-metal on a large scale, on the sole condition that their steel shall meet the required tests. Unless such action be taken, the Government will be compelled to purchase its gun-metal abroad, for it will be unreasonable to expect private parties to invest over half a million dollars in plant without a definite prospect for its employment.

The facts that the United States is destitute of the means of fabricating the modern guns so urgently needed for national defense, and that at least three years will be required to complete the tools, construct

the shops and establish the plant, would seem to demand an immediate appropriation of the amount ($1,800,000) estimated for the establishment of the proposed gun factories.

E. SIMPSON,
Rear-Admiral, United States Navy, President of the Board.
E. O. MATTHEWS,
Captain, United States Navy.
T. G. BAYLOR,
Colonel of Ordnance, United States Army.
HENRY L. ABBOT,
Lieutenant-Colonel of Engineers,
Brevet Brigadier-General, United States Army.
SAM'L S. ELDER,
Major, Second Artillery, United States Army.
W. H. JAQUES,
Lieutenant, United States Navy,
Member and Secretary of the Board.

APPENDICES.

APPENDICES.

APPENDIX A.

[Copy of circular letter to steel manufacturers.]

COMMANDANT'S OFFICE, NAVY-YARD, LEAGUE ISLAND,
Philadelphia, May 1, 1883.

GENTLEMEN: I forward herewith a copy of a precept issued by the President of the United States, under the provisions of an act of Congress, appointing a Board charged with the duties mentioned in the order. Besides the consideration of the establishment of a Government foundry pure and simple, and the determination of the suitability for this purpose of any site now the property of the Government, the Board desires to be informed as to the disposition of the steel manufacturers in the country to assist the object to be attained, namely, to enable the Government to produce at home from its own material and manufacture the heaviest ordnance required for modern warfare.

The Board is informed of the propositions made to the steel manufacturers by the Chiefs of Ordnance under dates of February and April, 1883, in which certain requirements are presented, but in the calls thus made the size of the castings does not exceed what would be suitable for the tubes of 8-inch guns.

In considering the subject as now presented by the Board your attention is asked to the fact that its interrogatories are intended to include the manufacture of steel guns up to 100 tons weight. It is further desired that you will carefully consider the methods of manufacturing gun steel now employed in England, France, Germany and Russia, with a view to the selection of any of the methods for its manufacture.

The Board requests that you will consider the following problem, namely: Given your present plant, what aid would you require from the Government in order so to enlarge it as to be able to manufacture the heaviest ordnance, the work to include the entire process of manufacture from the casting of the ingots to the finishing of the gun. The Board would require an itemized statement of buildings, tools, hammers or apparatus, with estimates of cost.

Whether you conclude to consider this proposition or not, the Board requests a reply to its communication, and will be glad to answer any question you may be pleased to present.

Respectfully,

E. SIMPSON,
Commodore, United States Navy, President of the Board.

APPENDIX B.

[Circular letter to South Boston Iron Company and to Paulding, Kemble & Co.]

COMMANDANT'S OFFICE, NAVY-YARD, LEAGUE ISLAND,
Philadelphia, May 1, 1883.

GENTLEMEN: Referring to your communications of December 15, 1882, and January, 1882, to the honorable the Secretary of the Navy, and the Chief of Ordnance, War Department, in relation to the establishment of a plant capable of manufacturing the heaviest ordnance required for modern warfare, the Board asks your attention to the inclosed copy of a precept issued by the President of the United States in accordance with an act of Congress.

Your consideration is also requested of the inclosed copy of a communication addressed by the Board, constituted by the above-mentioned act, to the steel manufacturers of the United States.

The act of Congress under which the present Board is organized is in the direction pointed out by your communications above referred to, and the Board will be glad if you will revise your proposition and so modify it as to reply to the interrogatory submitted as a problem in the inclosed letter to the steel manufacturers, as follows: "Given your present plant, what aid would you require from the Government in order so to enlarge it as to be able to manufacture the heaviest ordnance, the work to include the entire process of manufacture from the casting of the ingots to the finishing of the gun."

Respectfully,

E. SIMPSON,
Commodore, United States Navy, President of the Board.

APPENDIX C.

6 OLIVER STREET,
Boston, May 8, 1883.

SIR: We have the honor to acknowledge the receipt of your circular letter dated the 1st instant, addressed to us, and also one of similar tenor addressed to the Norway Iron Works.

In reply to the same we regret to be obliged to say that, owing to contemplated changes at our works, we cannot at present hold out any prospect of being able to furnish the Government with steel guns such as are mentioned in your letter. Should we, at a later date, be in a position to supply them, we shall then be happy to take up the matter and furnish the board with estimates.

We are, sir, very respectfully, yours,

NAYLOR & CO.

Commodore E. SIMPSON, U. S. N.,
President of the Foundry Board, Navy-Yard, League Island, Philadelphia, Pa.

APPENDIX D.

WEST POINT FOUNDRY,
Cold Spring, May 10, 1883.

SIR: We beg leave to acknowledge the receipt of your communication of May 1. The problem proposed to us is a difficult one, and we would inquire how much time you can allow us to look into the matter.

We would also ask you if you are correct in assuming that guns will be required from 6-inch to about 16-inch caliber, and if you can give some idea of the number of each kind which such an ordnance establishment should produce in the course of a year to meet the wants of the Government.

Very respectfully, your obedient servants,

PAULDING, KEMBLE & CO.

Commodore E. SIMPSON, U. S. N.,
President of Board, Navy-Yard, League Island.

APPENDIX E.

PARK, BROTHER & CO.,
Pittsburgh, Pa., May 10, 1883.

DEAR SIR: We are in receipt of your esteemed favor of 1st instant, and carefully note contents. We will take the matter into consideration, and write you further on the subject in a few days.

Yours, truly,

PARK, BROTHER & CO.

E. SIMPSON, Esq.,
Commodore, United States Navy, President of Foundry Board, Washington, D. C.

APPENDIX F.

OFFICE OF THE SOUTH BOSTON IRON WORKS,
70 *Water Street, Boston, May* 12, 1883.

SIR: I have the honor to acknowledge receipt of your communication of 1st instant with inclosures named. I have given much consideration to the subject concerning which you make inquiry, and realize its great importance. I propose to thoroughly study the question and obtain expert assistance in making such investigation, and in preparing such estimates and plans in detail as will enable me to present to your Board the design of a practicable plant for the manufacture of heavy ordnance adapted to modern warfare, including a steam hammer or apparatus of sufficient size for the manufacture of the heaviest guns.

It will be three or four months before I shall have completed this work, as I contemplate a visit to the important establishments in Europe for consultation and observation.

Meanwhile, remain very respectfully, your obedient servant,

WM. P. HUNT,
President South Boston Iron Works.

Commodore E. SIMPSON, U. S. N.,
President, &c., Commanding League Island Navy-Yard, Philadelphia.

APPENDIX G.

PITTSBURGH, PA., *May* 22, 1883.

DEAR SIR: Your favor under date of May 1 is at hand. Replying thereto we beg to say that we fear the expense of altering and adding large additional machinery to our present plant, which is new and improved, would be more than the Board would entertain. Our location in this market we claim is as good, if not better, than that of others for the shipping and hauling of heavy shapes, either by the Ohio River or by rail, and if the extra machinery was added to our plant, the ordnance required could be produced as cheaply and as effectively as at any other point in the country.

We would not entertain a proposition that would leave us high and dry when the present honorable commission retired, but must be guaranteed or subsidized for at least ten or fifteen years. This would insure safety to ourselves for changing, or allowing to be changed, our present plant, which is already adapted to turning out in the neighborhood of 12,000 tons of steel per annum, and would, we feel, be more satisfactory to the Government.

If the honorable Board would outline for us the size of plant governed by the number of guns, tonnage, &c., required, and about the sum the Government would limit itself to invest, we could more accurately inform ourselves what would be necessary.

We are, sir, yours respectfully,

PITTSBURGH STEEL WORKS,
ANDERSON, DU PUY & CO.

Hon. E. SIMPSON, Esq.,
Commodore, United States Navy,
President Board of Ordnance, Philadelphia, Pa.

APPENDIX H.

THE MIDVALE STEEL COMPANY,
Nicetown, Philadelphia, May 26, 1883.

DEAR SIR: Your circular letter of May 1, calling the attention of this company to the existence of the Board of which you are president, and to the object for which it has been created, came duly to hand and would have received a more prompt acknowledgment had we not been prevented from presenting the matter to the attention of our president, Mr. Wm. Sellers.

This company has given the subject of the manufacture of steel for ordnance considerable attention, and has had some success in the production of pieces of a moderate size—such, for instance, as are required for 6-inch breech-loading guns.

Our capacities are at present very limited for this sort of work, heavier than the above mentioned; but, from our past experience, we feel confident that in case we could be insured a sufficient amount of work to make the undertaking remunerative, we could, with proper appliances, produce successfully large masses of steel for ordnance purposes.

In considering the matter with a view of answering the Board's inquiry as to what additions would have to be made to our present plant in order to enable us to produce the parts of a 100-ton steel gun, we would now ask the Board to kindly furnish to us the approximate dimensions of the largest masses of steel required in the construction of a gun of this weight. We could then consider, more intelligently, the problem in question.

Awaiting the Board's reply, we remain,

Yours, respectfully,

R. W. DAVENPORT,
Superintendent.

Commodore E. SIMPSON, U. S. N.,
President Foundry Board, Navy-Yard, Philadelphia.

APPENDIX I.

PITTSBURGH, PA., *May* 24, 1883.

DEAR SIR: Referring again to your esteemed favor of 1st instant, would say our Mr. William G. Park will probably be in Philadelphia within a week and will then see you and discuss the subject thoroughly.

Yours, truly,

PARK, BROTHER & CO.

E. SIMPSON, Esq.,
Commodore, United States Navy,
President of Foundry Board, League Island, Philadelphia, Pa.

APPENDIX J.

SPRINGFIELD, ILL., *June* 2, 1883.

DEAR SIR: Your letter of May 1, in regard to the establishment of works for the manufacture of heavy steel guns was duly received and has been considered. In reply, I have to say that this company has a plant consisting of three "Pernot" open-hearth steel furnaces, so arranged that we can readily cast ingots weighing say 40 gross tons. We could also easily arrange to increase the weight to 50 tons, and by the addition of one or two furnaces to 75 or even as high as 90 tons. I am not very familiar with the nature of the tools and other appliances which would be necessary to finish the different parts of the gun from the ingot; but suppose we have but little, if anything, in our plant that would apply. For this same reason I am not prepared to furnish an estimate of the amount of aid which we would require to enable us to prepare ourselves for the undertaking which you have in view. I can say, however, that we would be glad to co-operate with the Government in establishing a plant of the kind wanted, and that we would fit up our works with everything necessary upon being satisfied that it would receive a fairly remunerative business by so doing. Or we will, if it is preferred, and time can be given, procure estimates of the cost of whatever may be needed, and allow the Government to furnish the same on any fair understanding as to what compensation we shall receive for the use of what we now have. In this latter case, we would request that you furnish the specification for an outfit of such a kind as you think will be best adapted to the purpose in view.

We think that this place affords some advantages for the business in contemplation. It is far enough inland to be at all times safe from interference from a foreign foe. Our transportation facilities are ample. We have an abundance of exceedingly cheap fuel and easy access to the best raw materials to be had in Missouri or on Lake Superior.

This company has been operating an iron-rail mill and bar mill very successfully for about twelve years, and is just completing a large mill for rolling steel plates of any thickness, and up to 110 inches wide. It is expected that this mill will be fully equal

to anything of the kind in the country. It is possible that it may be to the advantage of the Government to take some ship plates from this mill at some future time for use at some of the various navy-yards or on the western interior waters. It is also possible that our bar mill may be of use in furnishing some of the lighter parts to be used in the manufacture of steel guns of moderate weight.

Asking the favor of a reply, I am, yours, respectfully,

C. RIDGELY,
President.

Commodore E. SIMPSON, U. S. N.,
President Foundry Board, League Island, Philadelphia.

APPENDIX K.

SOUTH BOSTON IRON WORKS,
Boston, January 16, 1884.

SIR: Referring to your communication of May 1, 1883, inviting me to revise my proposition of January, 1882, referred to, and so modify it as to state what aid I should require of the Government to enable me to so enlarge our present plant as to be suitable for the manufacture of the heaviest ordnance required for modern warfare from the crude material, I now beg to say I have considered the problem carefully, and conclude that the subject is so important and comprehensive—so much depending upon information obtainable only in Europe, and of which I have obtained very little, compared with that in possession of your Board—I had better confine my estimates in reply to that portion of the proposed plant of which I have some practical knowledge, and so have considered the cost of such additional machinery and tools as would, with our present plant, enable us to machine-finish, from the steel forgings or compressed ingots, modern steel guns at rates as follows:

Six guns of 16-inch caliber per year.
Twenty guns of 12-inch caliber per year.
Twenty guns of 10-inch caliber per year.
Thirty guns of 8-inch caliber per year.
Forty guns of 6-inch caliber per year.

I estimate the amount required to bring our plant up to this capacity would be $800,000, and require two years' time.

We desire to make this enlargement as soon as practicable, and ask the Government to advance the necessary money, under proper guards and restrictions, to be reimbursed to the Treasury when a reserve of 5 per cent. of all the income from said machinery and tools shall amount to a sum sufficient. With a reasonable volume of business the Government would be repaid in full within ten years.

Should your Board recommend this method to be adopted for the manufacture of heavy ordnance, but wish to provide for a complete establishment capable of producing the steel from the casting of the ingots, as well as the machine finishing of guns, I beg to refer you to my letter of January, 1882, referred to, and say I am ready to undertake the construction of the complete establishment upon the same terms as proposed for the machine department. In that event, I should expect to unite our works with that of the West Point Foundry Association, and move to such locality as would be approved by the Government authorities.

Very respectfully, your obedient servants,

SOUTH BOSTON IRON WORKS,
By WM. P. HUNT, *President.*

Commodore E. SIMPSON, U. S. N.,
President Gun Foundry Board, Philadelphia.

APPENDIX L.

WEST POINT FOUNDRY,
Cold Spring, January 18, 1884.

SIR: Referring to your communications of May 1, 1883, respecting a plant to manufacture ordnance, we beg leave to make the following reply, which, in consequence of the questions asked us not being sufficiently definite, is necessarily approximate in its character.

Our establishment in its present state is capable of finishing a limited number of steel breech-loading guns, but is inadequate to the wants of the Government. We would leave it as it is, using it to the extent of its capacity for ordnance, and making projectiles, gun carriages, &c. (for which it is well adapted), if required. We would then propose to build an entirely new plant, independent of the old one on our property, capable of turning out about 120 guns per year, ranging from 100 tons to 6-inch caliber or less, the necessary steel forgings to be furnished to us. We estimate the cost of such a plant, including buildings, engine and boilers, lathes, cranes, and other machinery, about $800,000.

As it would be impossible for us to procure the means to put up such a plant, the only plan which seems feasible to us is for the Government to advance the necessary amount under such conditions as may be deemed proper, and with a proviso for its ultimate repayment when 5 per cent. of the amount of ordnance business done on said plant shall be equal to the sum advanced, the United States to remain proprietors of the plant until it is paid for as proposed.

With regard to the making of steel forgings, we understand that your Board has obtained in Europe the necessary information, and have more knowledge of the subject than we have been able to procure. We have, therefore, only to say that we should be willing to get up a plant on the terms proposed for the construction plant should it be considered advisable by the United States to locate it on our property or to combine it in the same establishment as that in which the ordnance is finished.

We estimate that it would require about two years to create the construction plant, but we are not prepared to state how long it would take to put up the plant for making the steel forgings.

Very respectfully, your obedient servants,

WEST POINT FOUNDRY ASSOCIATION,
G. PAULDING, *President.*

Commodore E. SIMPSON, U. S. N.,
Chairman of Gun Foundry Board, Philadelphia.

APPENDIX M.

OFFICE OF CAMBRIA IRON COMPANY,
Philadelphia, January 31, 1884.

DEAR SIR: Will you kindly advise us when it would be convenient for a representative of our company to appear before your Board in regard to securing such information as you can furnish us and making answer to your circular letter of May 1, 1883.

Awaiting your reply, we are yours, truly,

POWELL STACKHOUSE,
Vice-President.

Commodore EDWARD SIMPSON,
President Foundry Board, 1727 Pine street, Philadelphia, Pa.

APPENDIX N.

OFFICE OF CAMBRIA IRON COMPANY,
Philadelphia, February 7, 1884.

DEAR SIR: Having received the impression that the Gun Foundry Board would, after its investigations in Europe, be prepared to give us some information that would assist in a reply to its circular letter of May 1, 1883, we have delayed submitting any proposition that would indicate our "disposition to assist the object to be obtained," or an estimate of the manner and amount of "aid" required "from the Government."

We are now informed by the Board that such information cannot, without injustice to other private interests, be given before the publication of its report. We, therefore, have the honor to submit the following, suggested by our long and valuable experience in the manufacture of steel, and our investigations upon the subject matter of the Gun Foundry Board's letter of May 1, 1883.

As requested in that letter, we have (as far as time would permit, and as carefully as possible without making a special visit to Europe) considered "the methods of manufacturing gun steel now employed in England, France, Germany and Russia, with a view to the selection of any of these methods for its manufacture." This careful consideration indorses the statement we have already made in person to your Board, that steel made by the open-hearth process is the most uniform; and that we believe we have the largest casting plant on this system in the United States, conducted by men of great experience. We further are of the opinion that our casting plant will meet the *present* requirements of the Government for gun metal, and if a sufficiently large contract or other guarantee against loss were given, we could rapidly develop it to meet increasing demands.

Like all other steel manufactories in the United States, we have no apparatus capable of forging the large ingots required for modern guns. Before embarking in a forging plant that must require an expenditure of from a quarter to a half million of dollars, we would await the opinion of the Board or the action of the Government in regard to the adoption of a hammer or a hydraulic press. We have been led to this conclusion by the great attention which is now given this question in England and the use of a hydraulic casting press in Russia; also, by the fact that a large number of shafts for English naval ships and a large quantity of steel furnished the Royal Arsenal and the works of Armstrong, Mitchell & Co., have been manufactured by Sir Joseph Whitworth, who casts and forges the steel for these purposes by hydraulic presses.

As the forging press is said to be cheaper and its effect equal to or better than the hammer, we would naturally adopt that method of forging, unless the Government in its contracts should require the metal forged with the hammer.

Our company has received invitations from the Ordnance Departments of both Army and Navy to furnish gun material, the castings for which are well within our capacity to make; but wanting a suitable apparatus to properly forge such castings, and in the absence of a sufficiently large contract to pay even the cost of small apparatus, and the risks attendant upon the development of a new branch of our industry, we did not deem it wise to undertake a small contract.

In regard to the problem you submitted, "Given your present plant, what aid would you require from the Government in order so to enlarge it as to be able to manufacture the heaviest ordnance, the work to include the entire process of manufacture from the casting of the ingots to the finishing of the gun," we have to state we have learned that England and France, two of the countries mentioned in your letter, separate the manufacture of the steel from the construction of the guns. As they have had long and valuable experience upon this subject it would seem that they have adopted this plan because it was the best.

In view of this fact we submit an approximate estimate of the amount to be expended to put our plant in a condition to supply the required steel for gun construction.

For the sum of $695,000 we could add to our present plant forging apparatus, tools to rough bore and turn, and appliances for tempering the material of such weight and sizes as we suppose the Government will demand. Of the above-named sum, $143,000 we estimate as duty at 45 per cent ad valorem on tools it will be necessary to import from foreign makers experienced in their construction.

We desire to call the attention of the Board to the following statement of business facts and considerations, that it may judge of the capacity, both financially and technically, of the Cambria Iron Company to undertake the work required of a national foundry.

The works of the company are located at a sufficient distance from the seaboard to render them absolutely secure from attack by a foreign enemy, while at the same

time they do not occupy an isolated position so that communication between them and the exposed portions of the country would be either impossible or difficult for our own people. The works are situated directly on the main line of the Pennsylvania Railroad, which affords quick and safe communication between the East and the West, and also brings them within 80 miles of steamboat communication on the Ohio River at Pittsburgh. In addition to these transportation facilities, the works are also in direct rail communication with the Southern seaboard and the South itself by way of the Somerset and Johnstown Railroad, which is a thoroughly-built and well-equipped branch of the Baltimore and Ohio Railroad, which has eastern termini at Baltimore and Washington and Southern connections at these and other points; also a third trunk line between the seaboard and West, now under construction, passing a few miles south of Johnstown, and with which there will be direct connection. It may also be added that by way of the Pennsylvania Railroad and its connections at Harrisburg with the Northern Central Railway the works have an additional outlet to Baltimore, Washington, and the South.

The situation of the works of the Cambria Iron Company at Johnstown is one of great healthfulness, and it is comparatively sheltered from the extremes of both heat and cold, and is wholly free from all malarious influences, so that workmen can prosecute their various employments in all seasons without danger of interruption from intense heat or cold, or from the prevalence of epidemics. The healthfulness of the situation of the works, the constant employment which has been given to its workmen for twenty-nine years, the cheapness of the necessaries of life, and the facilities which have been afforded by the company for the acquisition of homes by heads of families, have greatly contributed to the building up at Johnstown and in its immediate and dependent suburbs of a steady, sober, intelligent, and moral class of skilled mechanics—a fact upon which we desire to place great stress, as an industrial community that is fixed and permanent and attached by home ties and associations to its place of employment is far less likely to engage in contentions and strikes at critical periods than one that is composed of floating and uncertain elements.

The works have been in existence and in operation for more than thirty years, and in this time an army of skilled workmen has been gathered together that for efficiency, fidelity and variety of scientific and mechanical attainments, is believed to be unsurpassed, if equaled, in our whole country.

The works of the Cambria Iron Company are not merely of a reproductive or finishing character, but they embrace every branch of a complete establishment devoted to the manufacture of iron and steel. The company owns its own coal mines, including extensive mines in the Connellsville coke region and other mines adjacent to the works at Johnstown; it owns its own iron-ore mines, some of which are adjacent to the works, while others are situated in the Lake Superior region and elsewhere; it produces its own pig-iron in furnaces that possess all the modern improvements; it has a large Bessemer steel-plant, a large open-hearth steel plant, iron and steel rail and other rolling-mills, puddling and heating furnaces, wire mills, and facilities for the production of miscellaneous steel products.

The works have a capacity for the production of 300,000 tons of pig-iron and over 200,000 tons of steel per annum.

The company employs at the present time 9,000 workmen. It has its own mining and mechanical engineers, its own draughtsmen, and its own chemists.

These details are mentioned to show the varied experiences of the employés and officers of the company; its perfect control over the raw materials it uses, and consequently over the character of all its products, and the facilities generally for the prompt addition to its works for the contemplated national foundry, and the equally prompt and faithful execution of such orders as would be required of it.

It only requires to be added that the financial ability of the Cambria Iron Company to comply with all its engagements cannot be questioned. * * * It owns absolutely all of its property, without intervening creditors, as it has no bonded nor floating debt; all its employés are regularly paid every month; it can always manufacture all the articles it now produces as cheaply as any of its competitors, and hence is in no danger of ever abandoning business as a manufacturer of iron and steel. If financial ability to execute a contract is desirable, then the Cambria Iron Company may truthfully be said to possess that requirement in an eminent degree; and if a reputation for energy, enterprise, conscientiousness, and complete success in the production of iron and steel of the best qualities counts for anything, the Cambria Iron Company, it may also be truthfully said, possesses this reputation and has possessed it for many years.

In conclusion, we desire to inform the Gun Foundry Board that the Cambria Iron Company may be induced to undertake at once the development of its steel plant to meet the requirements for gun material if the United States Government will make a sufficiently large contract or give other positive guarantee which shall insure the Cambria Company adequate employment or sufficient profit to reimburse this large expenditure, the company on its part undertaking to meet the required tests.

If the Government desires to enter into any joint action by furnishing the means for the development of a plant, with a reserve for reimbursement, the foregoing statements indicate our ability to undertake such action under the most favorable conditions for the faithful execution of the work.

All of which is respectfully submitted.

CAMBRIA IRON COMPANY,
By E. Y. TOWNSEND, *President.*

Commodore E. SIMPSON, U. S. N.,
President of Foundry Board.

APPENDIX O.

BROWN'S HOTEL, DOVER STREET,
London, England, July 30, 1883.

SIR: I am requested by the Board appointed by the President, under a late act of the United States Congress, to examine and to report on matters relating to the manufacture of cannon, to address you on the subject of a visit which we desire to make to the works of Mr. Fried. Krupp, at Essen.

From our preliminary conversation of this morning I understand your position to be at the outset as follows: That if the examination of the Board be confined to a study of the works for the purpose of gaining information for our Government, without holding out any prospect of ultimate advantage to the factory through purchase of material, the request for admission will not be granted.

In reply to this I desire to state that though this Board is not authorized in any way to commit the United States Government to any course of action, yet the recommendations that it may make are entirely at its own discretion.

The members of the Board are well aware of the great expense necessary before a gun-foundry establishment can be brought to a state of practical usefulness; they are also aware of the length of time that must elapse before a plant can be established or satisfactory work produced, and if it should be concluded by the United States Congress to supplement the present inquiry by directing that armaments shall be provided at once, it is very probable that the recommendations of this Board would be to purchase abroad.

In such a case, the information that we might gain by a close examination of the manufacture of steel and the fabrication of guns and ammunition at the works of Mr. Krupp might greatly influence the direction of our recommendations.

If this view of the case will satisfy the implied condition of ultimate profit to the establishment, I will be glad to hear from you to that effect, and I request that this communication may be received as an official application for permission to visit the works.

Very respectfully,

E. SIMPSON,
Commodore, United States Navy, President of the Board.

(Care of B. F. Stevens, United States Dispatch Agent, 4 Trafalgar Square, Charing Cross, London.)

ALFRED LONGSDON, Esq.

APPENDIX P.

[Fried. Krupp's Cast-Steel Works, Essen, Rhenish Prussia.]

9 NEW BROAD STREET,
London, July 31, 1883.

SIR: I am duly in receipt of your esteemed favor of the 30th instant, which accurately recapitulates the substance of our conversation yesterday. I have now fully laid the matter before my Essen firm, and trust in a few days to write you fully thereon, and trust that a satisfactory solution of the question may be found; and in mean time, believe me, sir,

Yours, faithfully,

Pr. Pro. FRIED. KRUPP,
ALFRED LONGSDON.

BROWN'S HOTEL, *Dover Street, W.*
Commodore E. SIMPSON, U. S. N.,
President of the Gun Foundry Board.

APPENDIX Q.

[Fried. Krupp's Cast-Steel Works, Essen, Rhenish Prussia.]

9 NEW BROAD STREET,
London, August 13, 1883.

SIR: I am now enabled to reply to your valued favor of 30th July, which has had the consideration of my Essen firm, and I beg to submit to you the following:

As it is presumed that your Commission has for its chief purpose the examination of the ordnance question in its characteristic of artillery efficiency, more than as a system of manufacture, which must be secondary, there does not appear to be so much necessity to see the works at Essen, where no data could be taken as to the value of the Krupp system as pieces of artillery. It would be of much higher consequence to you to examine the question of efficiency by a course of practice at the artillery practice ground at Meppen, where guns of different calibers could be fired for all the essential ballistic properties attaching to them.

It is therefore proposed to place at your disposal the practice-ground at Meppen, and to fire there the different guns on the ground for range, accuracy, and general efficiency, and I shall be very glad if this meets with your acceptance. It is, however, of consequence that this should be decided without loss of time, because we are not allowed to fire after *September* 1 *till October* 15, on account of the harvest in the neighborhood. It will, therefore, be essential that the trials take place *this month*, and if you will kindly give me your decision a programme shall be drawn up for, say, the last days of the month. You may be sure that everything shall be done at Meppen to give you every information upon the superiority of our system of artillery. I shall be glad to have a telegram from you as early as possible, stating your decision, as I am leaving for Essen on Thursday morning.

The works at Essen cannot be seen, as these are closed to all but those who have special business of inspection of war material on order.

I am, sir, yours, obediently,

Pr. Pro. FRIED. KRUPP,
ALFRED LONGSDON.

Commodore EDWARD SIMPSON,
President of the American Artillery Commission.

APPENDIX R.

[Telegram.]

NEWCASTLE-ON-TYNE, ENGLAND,
August 14, 1883.

ALFRED LONGSDON,
9 *New Broad Street, London, E. C.:*

The Board regrets that it will be unable to accept the offer contained in yours of 13th instant. Letter by mail.

Commodore E. SIMPSON,
County Hotel, Newcastle-on-Tyne.

APPENDIX S.

THE COUNTY HOTEL,
Newcastle-on-Tyne, England, August 15, 1883.

SIR: On the part of the United States Gun Foundry Board, I have the honor to acknowledge the receipt of your favor of the 13th instant, in which I am informed that "the works at Essen cannot be seen, as these are closed to all but those who have special business of inspection of war material on order."

As the application of the Board was for permission to visit the works at Essen, your reply is therefore a notification that the request is refused.

The members of the Board appreciate your courtesy in placing at their disposal the practice-ground at Meppen, and your offer to exhibit the firing of guns for range, ac-

curacy, and general efficiency; but notwithstanding the great interest that would be taken in such experiments by the members of the Board, it is considered that the object of their mission would not be furthered thereby. With many thanks, therefore, for your considerate offer to view the efficiency of the Krupp manufacture by means of a course of practice, we regret our inability to accept it.

You will allow me to demur to your conclusion that "your Commission has for its chief purpose the examination of the ordnance question in its characteristics of artillery efficiency." On the contrary, it has for its object more the "system of manufacture," and I refer you to my letter of July 30, in which this view is presented.

Very respectfully,

E. SIMPSON,
Commodore, United States Navy, President of the Board.

FRIED. KRUPP'S CAST-STEEL WORKS, ESSEN, RHENISH PRUSSIA,
9 *New Broad Street, London, E. C.*

APPENDIX T.

[Fried. Krupp's Cast-Steel Works, Essen, Rhenish Prussia.]

9 NEW BROAD STREET,
London, August 16, 1883.

SIR: I beg to acknowledge your esteemed favor of yesterday, which has been forwarded to Mr. Longsdon, who has gone to Essen.

I have the honor to be, sir, your obedient servant,

For FRIED. KRUPP,
WALTER COWAN.

Commodore E. SIMPSON, U. S. N.,
President of the Gun Foundry Board,
The County Hotel, Newcastle-on-Tyne.

APPENDIX U.

ESSEN, RHENISH PRUSSIA,
September 1, 1883.

SIR: Your favor of 15th ultimo has been forwarded to me here, and I very much regret that you have not accepted my desire to be of such service to you as I could, if not in all the objects of your mission to Europe, still to make yourself acquainted by personal observation of the efficiency and general characteristics of my artillery, for I had conceived that at least this would have formed the first necessity, and that the process of the manufacture of a gun would have been second to the conviction as to which is really the most efficient system of artillery.

If you recollect during our conversation in London I endeavored to clearly point out to you that it was hardly to be expected that the process of manufacturing artillery upon my system could be shown to you, a process only arrived at by an immense expenditure of time and money, while on your side no compensation would be guaranteed, and that we should thus be upon unequal terms; and from your favor of 15th ultimo I can now gather that a simple walk through the Essen shops would even not be all that you would require, but that the system of construction should be made clear to you—an amount of information scarcely to be expected.

I was sincerely desirous of giving you every means of examining my gun as a piece of effective ordnance, and I inclose you a programme I had proposed to myself should be followed, and I think you will be assured that I had every desire of being thus far of service to you. The outlay for such a programme would be £500 at least, so that I was fully prepared to sacrifice this in your interest, and if you can visit the practice-ground at Meppen after 15th October, I will do my utmost still to show you all the courtesy and attention I can in this direction.

Should you desire to have a series of reports of trials with my guns of various calibers, showing their capabilities, I shall be happy to have a collection of them made for your disposal.

I am, sir, yours, very truly,

Pr. Pro. FRIED KRUPP,
ALFRED LONGSDON.

Commodore EDWARD SIMPSON,
U. S. N., President of the Gun Foundry Board, London.

Draft of programme for United States Commission.

Caliber.	Numbers and kind of projectiles.	Pauses for—	Space of time.
			Minutes.
40-centimetre gun	2 common shells		20
		Change of position of frames	15
28-centimetre gun	5 armor-piercing shells		50
	5 common shells		25
		Change of position of frames	15
15¼-centimetre gun	5 common shells		30
		Advance	15
15-centimetre mortar	5 common shells		15
	5 shrapnels		25
		Rest, including advance	120
8.7-centimetre gun	5 shells, 5 shrapnels		40
Light 7.5-centimetre gun	5 shells, 5 shrapnels		30
7.5-centimetre mountain gun	5 shells, 5 shrapnels		30
15.5-centimetre shield gun	10 shells		20
15-centimetre pivot gun	5 shells		20
			470

470 minutes=7 hours 50 minutes.

APPENDIX V.

PARIS, FRANCE, *September* 17, 1883.

SIR: On my return from an extended tour in France, I find your favor of the 1st instant, which I have laid before the Commission, and to which I hasten to reply.

The "draft of a programme for the United States Commission," inclosed in your letter, is of a most elaborate character, and very strongly confirms the statement therein that you were desirous of giving the Commission "every means of examining my [your] gun as a piece of effective ordnance," and it is hardly necessary for me to repeat that such an exhibition would be of the greatest interest personally to the members of the Commission. The estimated outlay for such a programme (£500) impresses us with the extent of the sacrifice you were prepared to make in this regard in the interest of the Commission.

The question of the effectiveness of the Krupp gun as a piece of ordnance, however, is not one which at this day can be disputed. The battle fought at Meppen in 1879, though bloodless, and without an enemy in the field, settled this question most decidedly, and you cannot suppose that the members of this Commission are ignorant of the results that have ensued. It is to be regretted that no representatives from the United States assisted at those experiments; but the results are known throughout the world. To witness a partial repetition of them would be excessively interesting, but it would impart no new information.

You will thus see that a "personal observation of the efficiency and general characteristics of my [your] artillery" was not necessary in order to satisfy us of its power; and as the time at our disposal was limited and our course of investigation indicated, we were forced to suppress personal inclination, and to conclude that time spent as you proposed would not be justified by the especial object of our mission. The courtesy of your proposition was thoroughly recognized, and I trust that our reasons for declining your modification of our request are accepted as a necessity arising out of the circumstances in which we are placed.

After being notified by you that the "works at Essen cannot be seen, as these are closed to all but those who have special business of inspection of war material on order," the Commission established for itself a programme, including a visit to the Aboukhoff Works at Alexandrovsky, which will prevent it from entertaining the idea of visiting the practice-ground at Meppen after the 15th of October, as suggested in your favor of the 1st instant, to which this note is a reply.

In conclusion, I desire to say that this Commission, though organized by act of Congress, and with its members appointed by the President of the United States himself, does not presume to question the perfect right of the authorities of any establishment o exclude it from its premises. Such rights are exercised by Governments, and such

action is within the rights of any private corporation, and I deprecate the impression that may be conveyed that the non-attendance of the Commission at Meppen is the result of its exclusion from Essen.

The Commission is organized as a Gun Foundry Board; its essential work concerns itself with the arrangement of shops, the selection and position of tools, machines, &c.—in a word, with "installation." Matters of manufacture of metal, construction of guns, &c., come in as incidental, and bear much on the special object of its mission; but *gun-practice* is a luxury which can only be indulged in when the more essential features of its work do not engage the attention of the Commission.

Very respectfully,

E. SIMPSON,
Commodore, United States Navy, President of the Board.

FRIED. KRUPP, Esq.,
Per Alfred Longsdon, Esq.,
Essen.

RECORD OF PROCEEDINGS.

RECORD

OF THE

CONVENING SESSIONS AND PROCEEDINGS OF THE GUN FOUNDRY BOARD,

April 10, 1883, to February 8, 1884.

GUN FOUNDRY BOARD,
COMMANDANT'S OFFICE, NAVY-YARD, LEAGUE ISLAND,
Philadelphia, Pa., April 10, 1883.

The Board met at 10.45 a. m., in accordance with the precept issued by the President of the United States (File Book, p. 2), instructions received from the honorable Secretary of the Navy (File Book, p. 1), and order of Commodore Edward Simpson, U. S. N., senior member (Letter-Press Book, p. 3), and organized as follows:

Commodore Edward Simpson, United States Navy, member, president of the Board.
Capt. Edmund O. Matthews, United States Navy, member.
Col. Thomas G. Baylor, Ordnance Department, United States Army, member.
Lieut. Col. Henry L. Abbot, Engineer Corps, United States Army, member.
Maj. Samuel S. Elder, Second Artillery, United States Army, member.
Lieut. William H. Jaques, United States Navy, member, secretary of the Board.

All members present.

The precept and instructions were read by the president.

After discussion, the following were accepted as the principal requisites of location and adaptability of site:

Defensibility.
Possibility of expansion.
Convenience of proving and testing.
Proximity of iron.
Proximity of coal.
Proximity of skilled labor.
Proximity of water communication.
Character of foundation.
Salubrity of climate.

It was also decided to prepare letters to the Secretaries of War and the Navy asking for any information in their possession relating to the description, capacity, and cost of the equipment of European arsenals and foundries capable of casting and manufacturing the largest guns. Also, for plans of the various navy-yards and arsenals, said plans to cover the accepted requisites of location and adaptability

It was further decided to prepare a circular letter to the steel manufacturers and gun factors asking what Government assistance would be necessary to enable them to undertake the casting and manufacture of the largest guns, inclosing copies of Army Ordnance Circular Letter and Army General Order No. 20. To be included in this is the estimate of a steam hammer for or other means of the manufacture of 80 and 100 ton guns.

After further discussion of plan of action, the Board, at 2 p. m., adjourned subject to call of president.

GUN FOUNDRY BOARD,
COMMANDANT'S OFFICE, NAVY-YARD, LEAGUE ISLAND,
Philadelphia, Pa., May 18, 1883.

Board met at 10.45 a. m., in pursuance of the order of its president of May 9, 1883. All members present.

The record of the last meeting was read and approved.

The Board then proceeded to read and file communications. (File Book A, Nos. 12, 13, 15, 16, 18, 19, 20, 27, 28, 30, 31, 36, 37, 38.)

Read, considered, and placed on file the following correspondence: From Mr. Thomas S. Kennedy, of Louisville, Ky., offering his homestead as a site for the proposed foundry (File Book 6, 7, 8, 9, 33); from Senator Mahone, of Petersburg, Va. (File Book 24); and from Mr. George F. Tyler, president of the Norfolk and Western Railroad Company (File Book 29); and from Morgan, Williams & Co. (File Book 11).

The Board then proceeded with the discussion of the navy-yards and arsenals to be visited, and, after consideration of their location and adaptability, concluded for the present not to visit the following, viz: Beaufort naval station, S. C.; Key West naval station, Fla; Mare Island navy-yard, Cal.; Pensacola navy-yard, Fla.; Augusta Arsenal, Ga.; Benicia Arsenal, Cal.; Fort Monroe Arsenal, Old Point Comfort, Va.; Indianapolis Arsenal, Ind.; Kennebec Arsenal, Augusta, Me.; New York Arsenal, Governor's Island, New York Harbor; and San Antonio Arsenal, Texas, leaving the following to be visited, viz: Boston navy-yard, Mass.; League Island navy-yard, Philadelphia, Pa.; New London naval station, Conn.; New York navy-yard, N. Y.; Norfolk navy-yard, Va.; Portsmouth navy-yard, N. H.; Washington navy-yard, D. C.; Allegheny Arsenal, Pittsburgh, Pa.; Frankford Arsenal, Philadelphia, Pa.; Springfield Armory, Mass.; Rock Island Arsenal, Ill.; Watertown Arsenal, Mass.; and Watervliet Arsenal, West Troy, N. Y.

On motion, it was voted that the president of the Board be requested to communicate with the Secretaries of War and the Navy upon the subject of the advisability of visiting gun foundries in Europe, which, in its opinion, is necessary to gain the desired information.

After discussion of the course to be pursued in making the designated visits, the Board inspected the navy-yard, League Island, Philadelphia, and adjourned at 2.30 p. m. to meet in Norfolk, Va., on Tuesday, the 29th instant, to examine the Norfolk navy-yard.

GUN FOUNDRY BOARD,
Norfolk, Va., May 29, 1883.

Board met at 10.30 a. m., pursuant to adjournment. All members present.

Visited and examined the Norfolk navy-yard for the purpose of determining the advantages of this location for a Government foundry. After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this yard until farther informed of the characteristics of other points to be visited in accordance with the President's order.

Read and filed communications, Pennsylvania Railroad (File Book 40), Anderson Du Puy & Co. (File Book 39), Park Bro. & Co. (File Book 42).

At 2 p. m. adjourned to meet in Washington, D. C., Wednesday, the 30th instant.

GUN FOUNDRY BOARD,
Washington, D. C., May 30, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.

Visited and examined the Washington navy-yard for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this yard until further informed of the characteristics of other points to be visited in accordance with the President's order. The Board also inspected the ordnance work in progress at this yard.

At 3 p. m. adjourned to meet in Pittsburgh, Pa., Thursday, the 31st instant, at 10 a. m.

GUN FOUNDRY BOARD,
Pittsburgh, Pa., May 31, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.

Visited and examined the Allegheny Arsenal, Pittsburgh, Pa., for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this arsenal until further informed of the characteristics of other points to be visited in accordance with the President's order.

The Board also visited the Black Diamond Steel Works of Messrs. Park Brothers, and examined the operation of the seventeen-ton hammer, one of the largest in the United States. An investigation of the manufacture of steel at this establishment showed the metal was entirely produced by the Siemens process, applied not only to the open-hearth method, but also to the furnaces in which the crucible steel is made.

At 5 p. m. adjourned to meet in Johnstown, Pa., Friday, June 1, at 11 am.

GUN FOUNDRY BOARD,
Johnstown, Pa., June 1, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.

Visited the Cambria Iron Works, and witnessed the operation of the production of steel by the Siemens open-hearth rotary furnace, of which there were two in operation, and another in process of construction, of a capacity of about 20 tons each. The Board also inspected the blast furnaces, steel-rail mills, and other works of this large establishment.

At 5.50 p. m. adjourned to meet subject to call of the president.

GUN FOUNDRY BOARD,
Cold Spring, N. Y., June 14, 1883.

Board met at 1 p. m., pursuant to adjournment. All members present.

Visited the Cold Spring Foundry and Gun Factory of Messrs. Paulding, Kemble & Co., and examined its site and the capacity and condition of its plant. The Board then proceeded to read and file communications. (File Book 49, 51, 52.)

At 4 p. m. adjourned to meet in West Troy, N. Y., Friday, June 15, at 9 a. m.

WEST TROY, N. Y., *June* 15, 1883.

Board met at 9 a. m., pursuant to adjournment. All members present.

Visited and examined the Watervliet Arsenal, West Troy, N. Y., for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this arsenal until further informed of the characteristics of other points to be visited in accordance with the President's order.

At 1 p. m. adjourned to meet in Springfield, Mass., Saturday, June 16, at 10 a. m.

GUN FOUNDRY BOARD,
Springfield, Mass., June 16, 1883.

Board met at 10 a. m., pursuant to adjournment.

Visited and examined the National Armory. Springfield, Mass., for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this armory, until further informed of the characteristics of other points to be visited in accordance with the President's order.

Examined also the steam hammer, furnace, and hydraulic anvil erected in the works for the manufacture of the Hitchcock gun.

At 1 p. m. adjourned to meet in Boston, Monday, June 18, at 8.30 a. m.

GUN FOUNDRY BOARD,
Boston, Mass., June 18, 1883.

Board met pursuant to adjournment. All members present.

Discussed the suggested necessity of the employment of a mechanical expert and a recorder to accompany the Board during its European inspection, and concluded the employment of the latter was not necessary at the present time, and postponed action in regard to the former until the necessity of his services might be proved.

The Board then proceeded to Union Market, Mass., and examined the Watertown

Arsenal, for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this arsenal until further informed of the charactistics of other points to be visited in accordance with the President's order.

Examined also the Emory testing machine erected in these works and said to be the most excellent, delicate, and powerful testing machine in the world.

The Board then proceeded to Charlestown, Mass., and examined the Boston navy-yard, for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this navy-yard until further informed of the characteristics of other points to be visited in accordance with the President's order.

At 4 p. m. adjourned to meet at Portsmouth, N. H., Tuesday, June 19, 1883, at 8 a. m.

GUN FOUNDRY BOARD,
Portsmouth, N. H., June 19, 1883.

Board met at 8 a. m., pursuant to adjournment. All members present.

Visited and examined the navy-yard for the purpose of determining the advantages of this location for a Government foundry. After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this navy-yard until further informed of the characteristics of other points to be visited in accordance with the President's order.

At 11 a. m. adjourned to meet in Boston, Mass., Tuesday, June 19, 1883, at 2 p. m.

GUN FOUNDRY BOARD,
Boston, Mass., June 19, 1883.

Board met at 2 p. m., pursuant to adjournment. All members present.

Visited the South Boston Iron Works and Gun Factory, South Boston, Mass., and examined its site and the capacity and condition of its plant.

At 5 p. m. adjourned to meet in New London, Conn., Wednesday, June 20, 1883, at 10.30 a. m.

GUN FOUNDRY BOARD,
New London, Conn , June 20, 1883.

Board met at 10.30 a. m., pursuant to adjournment.

Visited and examined the New London naval station for the purpose of determining the advantages of this location for a Government foundry. After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this naval station until further informed of the characteristics of other points to be visited in accordance with the President's order.

At 3.30 p. m. adjourned to meet subject to call of the president.

GUN FOUNDRY BOARD,
New York, N. Y., July 18, 1883.

Board met on board Cunard royal mail steamer "Servia," and left the United States for England, in accordance with orders of the Secretary of War (File Book A, p. 53) and the Secretary of the Navy (File Book A, p. 45). All members present.

GUN FOUNDRY BOARD,
London, England, July 27, 1883.

Board met pursuant to the order of its president. All members present.

The president was requested to communicate with the United States minister to England, and ask his aid in obtaining permission to visit the Government establishments.

The Board then adjourned to meet Monday, the 30th instant, at 10 a. m.

GUN FOUNDRY BOARD,
London, England, Monday, July 30, 1883.

Board met at 10 a. m. pursuant to adjournment. All members present except Colonel Baylor, absent on account of sickness.

Sent communications. (Letter Book, pp. 118–120.)

Received and filed communications. (File Book B, p. 1.)

The Board then proceeded to pay an official call upon the honorable James Russell Lowell, United States minister, and accepted the invitation of Sir Joseph Whitworth, Bart., to call at his London office and inspect his systems of gun construction, projectile manufacture and armor plating, with specimens of machines for testing same.

Adjourned at 4 p. m. to meet at 8 p. m.

GUN FOUNDRY BOARD,
BROWN'S HOTEL, DOVER STREET,
London, England, Monday, July 30, 1883.

Board met at 8 p. m., pursuant to adjournment. All members present except Colonel Baylor, absent on account of sickness.

The Board proceeded to discuss plans for future action, and requested the president to communicate with the following-named manufacturers in relation to its proposed visit to their works, viz: Alfred Longsdon, Fried. Krupp's Cast-Steel Works, 9 New Broad street, London; Thomas Firth & Sons, Norfolk Works, Sheffield; Charles Cammell & Co., Sheffield; Sir John Brown & Co., Sheffield; Sir William Armstrong, Mitchell & Co., Elswick, Newcastle-on-Tyne; Messrs. Vickers, Sons & Co., Sheffield; and Henry Bessemer & Co., Sheffield.

The president was also requested to address a letter to the honorable L. P. Morton, United States minister to France, asking his kind offices in securing, in advance of the arrival of the Board, permits from the French Government to visit their works at Puteaux, Ruelle, Bourges, Gâvre, and Sevran-Livry.

Sent communication. (Letter Book, p. 123.)

At 10.30 p. m. adjourned to meet Wednesday, August 1, at 9.30 a. m.

GUN FOUNDRY BOARD,
London, England, Wednesday, August 1, 1883.

Board met at 9.30 a. m., pursuant to adjournment. All members present except Colonel Baylor, absent on account of sickness.

Received from English war office, through Lieutenant-Commander Chadwick, naval attaché, and in answer to his request a "list of machinery employed in the construction of steel B. L. guns in the Royal Gun Factory, Woolwich, together with a list of the addresses of the firms from whom the necessary appliances are procurable."

Sent communications. (Letter Book, pp. 126–132.)

Read and filed communication. (File Book B, p. 2.)

The Board then proceeded to the Royal Arsenal at Woolwich and visited the gun factories, after which it adjourned to meet to-morrow, Thursday, at 10 a. m.

GUN FOUNDRY BOARD,
BROWN'S HOTEL, DOVER STREET,
Thursday, August 2, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.

Read and filed communications. (File Book B, pp. 4, 5.)

Received a visit from Mr. Greenwood, of the firm of Greenwood & Batly, tool manufacturers, of Leeds. Discussed with him the subject of tools, particularly as to sizes and number requisite to perform certain work in a certain time. Mr. Greenwood proposed to prepare and submit to the Board a plan of works and an arrangement of shops and tools calculated to accomplish the work proposed by the Board.

Sent communications. (Letter Book, pp. 133, 134.)

The Board then visited and inspected the London Ordnance Works of Messrs. J. Vavasseur & Co., after which it adjourned to meet to-morrow, Friday, 3d instant, at 9.30 a. m.

GUN FOUNDRY BOARD,
London, England, Friday, August 3, 1883.

Board met at 9.30 a. m., pursuant to adjournment. All members present.
Read and filed communications. (File Book B, pp. 6–10.)
The Board then proceeded to the Woolwich Arsenal, visited the gun, carriage, and projectile factories, the laboratory, and witnessed a trial of the Vavasseur gun-carriage for 4-inch B. L. rifle.
Sent communications. (Letter Book, pp. 135–137.)
The Board then adjourned, to meet Tuesday, the 7th instant, at 9.30 a. m.

GUN FOUNDRY BOARD,
London, England, Tuesday, August 7, 1883.

Board met, pursuant to adjournment, at 9.30 a. m. All members present.
Read and filed communications. (File Book B, pp. 11–15 and 17.)
Sent communications. (Letter Book, pp. 138–143.)
The Board then proceeded to Woolwich Arsenal and continued its inspection, after which it adjourned, to meet subject to call of its president.

GUN FOUNDRY BOARD,
London, England, Wednesday, August 8, 1883.

Board met pursuant to adjournment. All members present.
Sent communication. (Letter Book, p. 145.)
Read and filed communication (File Book B, p. 16.)
Accompanied by Mr. J. Vavasseur, of London, and Lieutenant-Commander F. E. Chadwick, naval attaché to the legation, London, the Board proceeded to Sheffield, and adjourned, to meet to-morrow, Thursday, the 9th instant, at 10 a. m.

GUN FOUNDRY BOARD,
ROYAL VICTORIA HOTEL,
Sheffield, England, Thursday, August 9, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
The Board proceeded to the Norfolk Iron and Steel Works of Thomas Firth & Sons, Limited; witnessed a casting of crucible steel, and inspected the works.
Read and filed communication. (File Book B, p. 18*a*.)
Received from Varrall, Elwell & Middleton, constructing machinists, Paris, France, through Lieutenant-Commander Chadwick, tracings and descriptions of gun milling and drilling, breech-screw and planing and rifling machines now at Ruelle, France.
At 5.30 p. m. adjourned, to meet to-morrow, Friday, 10th instant, at 10 a. m.

GUN FOUNDRY BOARD,
ROYAL VICTORIA HOTEL,
Sheffield, England, Friday, August 10, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Sent communications. (Letter Book, pp. 146–148.)
Read and filed communication. (File Book B, p. 18.)
The Board then proceeded to the Atlas Steel and Iron Works of John Brown & Co., Limited, and witnessed the process of soldering iron and steel plates for armor, the Bessemer process of manufacture, and inspected the works.
At 3 p. m. the Board proceeded to the Iron and Steel Works of Charles Cammell & Co., Limited, and witnessed the formation of a compound armor plate by the process of a steel casting upon a wrought-iron plate prepared for the purpose. Inspected the Bessemer plant and other parts of the works.
At 5.30 p. m., adjourned to meet to-morrow, Saturday, the 11th instant, at 10 a. m.

GUN FOUNDRY BOARD,
ROYAL VICTORIA HOTEL,
Sheffield, England, Saturday, August 11, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Read and filed communication. (File Book B, p. 19.)
The Board then proceeded to the River Don Works of Messrs. Vickers, Sons & Co., Limited, and inspected the forge and machine shops, but were not invited to view the process of steel manufacture.
At 1 p. m. adjourned, to meet on Monday, the 13th instant, at 10 a. m.

GUN FOUNDRY BOARD,
ROYAL VICTORIA HOTEL,
Sheffield, England, Monday, August 13, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Read and filed communication. (File Book B, p. 22.)
The Board then proceeded to the Bessemer Steel Works of Henry Bessemer & Co., Limited; inspected the works, and witnessed a five-ton casting by the Bessemer process and mechanical mixer or stirrer.
The Board then adjourned to meet in Newcastle-on-Tyne, Tuesday, the 14th instant, at 8 p. m.

GUN FOUNDRY BOARD,
THE COUNTY HOTEL,
Newcastle-on-Tyne, England, Tuesday, August 14, 1883.

Board met pursuant to adjournment. All members present.
Read and filed communications. (File Book B, pp. 23–25.)
Sent communications. (Letter Book, pp. 149–152.)
The Board requested its president to communicate with the Fried. Krupp Cast-Steel Works, regretting the Board's inability to accept the kind invitation to witness, at Meppen, an exhibition of the general efficiency of the Krupp manufacture.
The president was also requested to communicate with the United States minister to Russia, and ask his aid in obtaining permission to visit the Government establishments there.
Adjourned to meet to-morrow, Wednesday, the 15th instant, at 10 a. m.

GUN FOUNDRY BOARD,
THE COUNTY HOTEL,
Newcastle-on-Tyne, England, Wednesday, August 15, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Sent communication. (Letter Book, p. 153.)
The Board then proceeded to the Elswick Works, Sir W. G. Armstrong, Mitchell & Co., and inspected part of the ordnance works.
At 2 p. m. adjourned to meet to-morrow, Thursday, the 16th instant, at 10 a. m.

GUN FOUNDRY BOARD,
THE COUNTY HOTEL,
Newcastle-on-Tyne, England, Thursday, August 16, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Sent communications. (Letter Book, pp. 155, 156.)
The Board then proceeded to Middlesbrough, and inspected the Cleveland Iron and Steel Works of Bolchow, Vaughan & Co., and witnessed the production of steel by the basic process.
The Board then returned to Newcastle-on-Tyne, and at 5.30 p. m. adjourned to meet to-morrow, Friday, the 17th instant, at 10 a. m.

GUN FOUNDRY BOARD,
Newcastle-on-Tyne, England, Friday, August 17, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Read and filed communications. (File Book B, pp. 26, 27.)
The Board then proceeded to a further inspection of the Elswick Works, Sir W. G. Armstrong, Mitchell & Co.
At 3 p. m. adjourned to continue the inspection of these works to-morrow, Saturday, the 18th instant, and to meet on Monday, the 20th instant, at 10 a. m.

AUGUST 18, 1883.

By direction of the president, sent communications. (Letter Book, pp. 158, 159.)

GUN FOUNDRY BOARD,
THE COUNTY HOTEL,
Newcastle-on-Tyne, England, Monday, August 20, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Read and filed communications. (File Book B, pp. 28, 29.)
Received accompanying drawings and descriptions of 4-foot sliding-gap lathe and 3-foot screw cutting and sliding lathe from Varrall, Elwell & Middleton, of Paris, France.
Sent communication. (Letter Book, p. 160.)
The Board then proceeded to make another visit to the Elswick Works, after which it adjourned to meet to-morrow, Tuesday, the 21st instant, at 11 a. m., in Leeds.

GUN FOUNDRY BOARD,
QUEEN'S HOTEL,
Leeds, England, Tuesday, August 21, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.
The Board proceeded to the offices and works of Messrs. Greenwood & Batey and inspected plans of machinery and tools for the manufacture of guns.
At 2 p. m. adjourned to meet to-morrow, Wednesday, the 22d instant, at 10 a. m., in Manchester.

GUN FOUNDRY BOARD,
QUEEN'S HOTEL,
Manchester, England, Wednesday, August 22, 1883.

Board met at 10 a. m. pursuant to adjournment. All members present.
The Board proceeded to the office and works of Messrs. Hulse & Co., and inspected plans of machinery and tools for the manufacture of guns.
At 1 p. m. adjourned to proceed to London, and meet subject to call of its president.

GUN FOUNDRY BOARD,
BROWN'S HOTEL, DOVER STREET,
London, England, Friday, August 24, 1883.

Board met at 8 p. m., at its president's call. All members present.
Read and filed communications. (File Book B, pp. 30, 31.)
Sent communication. (Letter Book, p. 161.)
After discussion, Board adjourned at 10 p. m., to meet in Paris, France, Wednesday, the 29th instant, at 10 a. m.

GUN FOUNDRY BOARD,
THE NORMANDY HOTEL, RUE DE L'ECHELLE,
Paris, France, Wednesday, August 29, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received communication. (File Book B, p. 42.)
The Board then proceeded to pay an official call upon the Hon. L. P. Morton, United States minister to France, and visited the works of the "Société Anonyme des Anciens Etabl'ts Cail," Paris.
The Board then adjourned to meet to-morrow, Thursday, the 30th instant, at 11 a. m.

GUN FOUNDRY BOARD,
THE NORMANDY HOTEL,
Paris, France, Thursday, August 30, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.
The Board then proceeded, in company with Minister Morton and his first secretary of legation, to call upon the military governor of Paris, in accordance with the request of the French minister of war of August 18th, and left communication (File Book B, p. 43), after which the Board adjourned to meet to-morrow, Friday, the 31st instant, at 9.30 a. m.

GUN FOUNDRY BOARD,
THE NORMANDY HOTEL,
Paris, France, Friday, August 31, 1883.

Board met at 9.30 a. m., pursuant to adjournment. All members present.
Received communication (File Book B, p. 43) from the military governor of Paris, with his indorsement.
The Board then proceeded to visit the Établissement d'Artillerie de Puteaux, near Paris; after which the Board adjourned to meet to-morrow, Saturday, September 1, at 11 a. m.

GUN FOUNDRY BOARD,
THE NORMANDY HOTEL,
Paris, France, Saturday, September 1, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.
After discussion, decided to leave Paris Monday, the 3d instant, at 8.45 a. m., for Angoulême, Bourges, Lyons, and Le Creusot.
The Board then proceeded to Sevran-Livry, near Paris, and inspected the powder factory and butts of Sevran-Livry.
Received and filed communications. (File Book B, pp. 34, 35.)
The Board then adjourned to meet Monday, the 3d instant, at 8 a. m.

GUN FOUNDRY BOARD,
Sunday, September 2, 1883.

Sent communications. (Letter Book, pp. 184–187.)

GUN FOUNDRY BOARD,
Paris, France, Monday, September 3, 1883.

Board met at 8 a. m., pursuant to adjournment. All members present.
The Board proceeded to Augoulême, France, by way of Orleans and Tours, to visit the gun factory of Ruelle.
Adjourned at 4 p. m. to meet to-morrow, Tuesday, the 4th instant, at 11 a. m.

GUN FOUNDRY BOARD,
GRAND HOTEL DU PALAIS,
Angoulême France, Tuesday, September 4, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.

Proceeded by carriage (40 minutes' drive) to Ruelle, and inspected the National Gun Foundry.

At 6 p. m. adjourned to meet to-morrow, Wednesday, the 5th instant, at noon.

GUN FOUNDRY BOARD,
Angoulême, France, Wednesday, September 5, 1883.

Board met at noon, pursuant to adjournment. All members present.

The Board then proceeded to Ruelle, and continued its inspection of the National Gun Foundry there.

At 6 p. m. adjourned to meet to-morrow, Thursday, the 6th instant, at 9.30 a. m.

GUN FOUNDRY BOARD,
Angoulême, France, Thursday, September 6, 1883.

Board met at 9.30 a. m., pursuant to adjournment. All members present.

The Board then proceeded, via Tours and Vierzon, to Bourges, where it arrived at 8.45 p. m., and adjourned, to meet to-morrow, Friday, the 7th instant, at 9.45 a. m.

GUN FOUNDRY BOARD,
GRAND HOTEL DE LA BOULE D'OR,
Bourges, France, Friday, September 7, 1883.

Board met at 9.45 a. m., pursuant to adjournment. All members present.

The Board then proceeded to pay an official call, accompanied by Lieutenant-Commander Chadwick, naval attaché to the legation, London, upon General Schnégans, commandant of the eighth army corps, and then visited and inspected the gun factory of Bourges; after which it adjourned, to meet to-morrow, Saturday, the 8th instant, at 8 a. m.

GUN FOUNDRY BOARD,
Bourges, France, Saturday, September 8, 1883.

Board met at 8 a. m., pursuant to adjournment. All members present.

The Board then proceeded to Lyons, France, via Sanscaize, Moulins, Roanne, and L'Arbresle, and adjourned at 9 p. m., to meet Monday, the 10th instant, at 8.30 a. m.

Received communications. (File Book B, pp. 36–38.)

GUN FOUNDRY BOARD,
GRAND HOTEL DE LYON,
Lyons, France, Sunday, September 9, 1883.

By direction of the president, sent communication. (Letter Book, p. 188.)

GUN FOUNDRY BOARD,
GRAND HOTEL DE LYON,
Lyons, France, Monday, September 10, 1883.

Board met at 8.30 a. m., pursuant to adjournment. All members present, except Colonel Baylor, absent on account of sickness.

The Board proceeded to Terre Noire, inspected the works of the "Compagnie des Fonderies et Forges de Terre Noire, La Voulte et Bessèges," and witnessed experiments with the Ripley-Hope steel gun of 127 millimetres.

The Board then returned to Lyons and adjourned to meet to-morrow, Tuesday, the 11th instant, at 9 a. m.

Received from the War Office, Horse Guards, S. W., London, England, through Lieut. Commander F. E. Chadwick, United States Navy, naval attaché, permit to visit the works of fortification at Dover Turret.

GUN FOUNDRY BOARD,
Lyons, France, Tuesday, September 11, 1883.

Board met pursuant to adjournment and proceeded to St.-Chamond. All members present.

Inspected the works of the "Compagnie des Hauts-Fourneaux, Forges et Aciéries de la Marine et des Chemins de Fer à St.-Chamond (Loire)," witnessed the rolling of a compound plate (manufactured by the Wilson patent), the casting of a 16-ton ingot, and the forging of an ingot of the same weight under the 80-ton hammer.

The Board then returned to Lyons, and adjourned to meet to-morrow, Wednesday, the 12th instant, at 10 a. m.

Received and filed communication. (File Book B, p. 44.)

GUN FOUNDRY BOARD,
Lyons, France, Wednesday, September 12, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.

Proceeded to Chagny, France.

At 8 p. m. adjourned to meet to-morrow, Thursday, the 13th instant, at 7.30 a. m.

GUN FOUNDRY BOARD,
HOTEL DU COMMERCE,
Chagny, France, Thursday, September 13, 1883.

Board met at 7.30 a. m., pursuant to adjournment. All members present.

Proceeded to Le Creusot and inspected a part of the steel works of Henri Schneider & Co. Witnessed the tempering of a 24-centimetre gun tube, and the casting of a 45-ton steel ingot.

At 5.30 p. m. adjourned to meet to-morrow, Friday, the 14th instant, at 8.30 a. m.

GUN FOUNDRY BOARD,
HOTEL RODERIGUE,
Le Creusot, France, Friday, September 14, 1883.

Board met at 8.30 a. m., pursuant to adjournment. All members present.

Continued the inspection of the Creusot steel works and witnessed the forging of a 75-ton ingot under the 100-ton hammer.

At 6.45 p. m. adjourned to meet to-morrow, Saturday, the 15th instant, at 8 a. m.

GUN FOUNDRY BOARD,
Le Creusot, France, Saturday, September 15, 1883.

Board met at 8 a. m., pursuant to adjournment. All members present.

Proceeded to Paris, via Chagny, Dijon, and Fontainebleau.

At 6 p. m. adjourned to meet Monday, the 17th instant, at 10 a. m.

GUN FOUNDRY BOARD,
THE NORMANDY HOTEL,
Paris, France, Monday, September 17, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.

Read and filed communications. (File Book B, pp. 39–41.)

It was resolved to select a committee to visit St. Petersburg, Russia, to further the work of the Board, and Captain Matthews, United States Navy, Lieutenant-Colonel Abbot, United States Army, and Lieutenant Jaques, United States Navy, were appointed members of such committee.

The following committees were also appointed:

Colonel Baylor and Major Elder, United States Army, to consult with the tool manufacturers of Manchester and Leeds, England, during the absence of the committee in Russia.

Captain Matthews, United States Navy, and Lieutenant-Colonel Abbot, United States Army, on buildings.

Colonel Baylor and Major Elder, United States Army, and Lieutenant Jaques, United States Navy, on the number and placing of tools in shops.

The Board requested the president to communicate with the Hon. W. H. Hunt, United States minister to Russia, in relation to the visit of the committee to Russia; with M. Henri Schneider, of Le Creusot; M. Euverte, director of the Compagnie des Fonderies et Forges de Terre Noire; M. de Mongolfier, the director of the Compagnie des Hauts-Fourneaux, Forges et Aciéries de la Marine et des Chemins de Fer à St.-Chamond (Loire); M. de Bange, the director of the Société Anonyme des Anciens Établissement Cail à Paris, acknowledging the courteous reception extended by them to the members of the Board; with the Hon. L. P. Morton, United States minister to France, acknowledging the assistance rendered by the military and naval authorities of France and his own personal courtesies; and with Fried. Krupp, of Essen, per Alfred Longsdon, acknowledging the receipt of his letter of the 1st instant and expressing the impossibility of accepting his modification of the Board's request.

Sent communications. (Letter Book, pp. 190, 166.)

At meridian Board adjourned to meet subject to call of its president.

GUN FOUNDRY BOARD,
Paris, France, Tuesday, September 18, 1883.

Board met at 2 p. m., at its president's call. All members present.

Accompanied by Minister Morton and his first secretary of legation, paid official calls upon the ministers of war and navy.

At 4 p. m. adjourned to meet subject to president's call.

GUN FOUNDRY BOARD,
Paris, France, Wednesday, September 19, 1883.

By direction of the president, sent communications. (Letter Book, pp. 171–177.)

GUN FOUNDRY BOARD,
From September 19 to *October* 5, 1883.

Committee of Board appointed to visit Russia engaged in its duties; other members of the Board occupied in France and England, revisiting the arsenal at Puteaux, collecting information on wire construction in France, inspecting the works of Messrs, Hotchkiss & Co., at St.-Denis, and compiling and arranging the information collected.

GUN FOUNDRY BOARD,
Paris, France, Wednesday, September 26, 1883.

Sent communication. (Letter Book, p. 180.)

GUN FOUNDRY BOARD COMMITTEE,
HOTEL DE FRANCE,
St. Petersburg, Russia, Monday, September 24, 1883.

Committee met at 10 a. m. All members present.

Proceeded to pay an official call upon the Hon. William H. Hunt, United States minister to Russia, who accompanied the committee to pay official calls upon the ministers of war and navy.

The committee then proceeded, in company with an aide-de-camp of General Obroutcheff, to pay an official call upon General Sophiano, chief of artillery, and adjourned at 3 p. m. to meet to-morrow, Tuesday, the 25th instant, at 9.30 a. m.

GUN FOUNDRY BOARD COMMITTEE,
St. Petersburg, Russia, Tuesday, September 25, 1883.

Committee met at 9.30 a. m., pursuant to adjournment. All members present.

Accompanied by Minister Hunt, proceeded to pay an official call upon the minister of the navy, Vice-Admiral Shestakoff (Le Vice-Amiral Shestakoff, aide-de-camp Général de S. M.).

The committee, accompanied by Captain Alexandre Von-der-Howen, Garde Artillerie (by direction of General Obroutcheff, acting minister of war) then proceeded to the St. Petersburg Arsenal ("Orondünoi Fawod") and inspected the work in hand, the small-arm ammunition shops and laboratory, after which, at 10 p. m., it adjourned to meet Thursday, the 27th instant, at 8 a. m. (Wednesday, the 26th instant, being a holiday).

GUN FOUNDRY BOARD COMMITTEE,
St. Petersburg, Russia, Thursday, September 27, 1883.

Committee met at 8 a. m., pursuant to adjournment. All members present.

Accompanied by Gunnery Lieutenant Raskazoff, Imperial Russian Navy (by direction of Admiral Shestakoff), proceeded in an admiralty steam launch to Oboukhoff, where the committee inspected the Oboukhoff Steel Works and Gun Factory.

At 5 p. m. adjourned to meet to-morrow, Friday, September 28, at 8 a. m.

Received communication. (File Book B, p. 49.)

Sent communications. (Letter Book, pp. 191, 192.)

GUN FOUNDRY BOARD COMMITTEE,
St. Petersburg, Russia, Friday, September 28, 1883.

Committee met at 8 a. m., pursuant to adjournment. All members present.

Accompanied by Gunnery Lieutenant Raskazoff and Captain Von-der-Howen, proceeded in the naval yacht Neva, Commander Satine, to Cronstadt, where, accompanied by Lieutenant-General Smaguine (commanding the artillery of Cronstadt) and staff, and Commander Skragin (representing Admiral Kazakewich), proceeded in steam launches to inspect the harbor, Forts Constantine and Milutin, the iron-clads "Peter the Great" and "Vladimir," and the naval torpedo manufactory.

At 7 p. m. returned to St. Petersburg, and adjourned to meet to-morrow, Saturday, the 29th instant, at 8 a. m.

GUN FOUNDRY BOARD COMMITTEE,
St. Petersburg, Russia, Saturday, September 29, 1883.

Board met at 8 a. m., pursuant to adjournment. All members present.

Accompanied by Gunnery Lieutenant Raskazoff, proceeded by carriage to the experimental grounds at Ochta, where, with Admiral Kouprianoff and staff and General Erme and staff, inspected the experimental batteries and armor targets.

At 3 p. m. adjourned to meet in London, Friday, October 5, 1883.

GUN FOUNDRY BOARD COMMITTEE,
London, England, Friday, October 5, 1883.

Committee met at noon, pursuant to adjournment. All members present.

The committee then proceeded to a general meeting of the Board.

GUN FOUNDRY BOARD,
London, England, Sunday, September 30, 1883.

Sent communication. (Letter Book, p. 193.)

GUN FOUNDRY BOARD,
BROWN'S HOTEL, DOVER STREET,
London, England, Friday, October 5, 1883.

Board met at meridian at its president's call. All members present.
Adjourned to meet to-morrow, Saturday, October 6, at 11 a. m.

GUN FOUNDRY BOARD,
London, England, Saturday, October 6, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.
The Board then proceeded to the London office of Sir Joseph Whitworth, Bart., for the purpose of listening to his explanations relating to his process of the manufacture of steels, guns, and projectiles, after which the Board accepted his invitation to meet him and inspect his works at Openshaw, Manchester, on Tuesday, the 9th instant, at 11 a. m.
Having returned to its room, the Board then received the memorandum notes of the committee, lately returned from Russia, and the record of its proceedings.
The Board then adjourned to meet Tuesday, October 9, in Manchester, England, at 10 a. m.

GUN FOUNDRY BOARD,
Manchester, England, Tuesday, October 9, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.
The Board then proceeded to and inspected the steel works of Sir Joseph Whitworth & Co. (Limited), at Openshaw, Manchester, and witnessed the casting, liquid compression, and hydraulic forging of steel by the Whitworth methods.
At 5 p. m. the Board proceeded to Rowsley, where, with Sir Joseph Whitworth, its deliberations were continued until 10 p. m., when the Board adjourned to meet in London, subject to call of its president.
The committee on number and placing of tools in shops was directed to proceed to Leeds, and upon the completion of its duties there to proceed to London.

GUN FOUNDRY BOARD,
London, England, Saturday, October 13, 1883.

Sent communications. (Letter Book, pp. 199, 200.)

GUN FOUNDRY BOARD,
BROWN'S HOTEL, DOVER STREET,
London, England, Monday, October 15, 1883.

Board met at call of its president.
After a visit to Woolwich Arsenal, the Board reassembled at 8 p. m. All members present.
Read and filed communications. (File Book B, pp. 45–57.)
Sent communications. (Letter Book, pp. 202, 203.)
The committee on tools reported its return from Leeds and Manchester, having completed its duties of inspecting the plans prepared for the information of the Board by Messrs. Greenwood & Batley and Tannett, Walker & Co., of Leeds, and Messrs. Hulse & Co., of Manchester. The Board then proceeded to read and examine various reports, and at 11 p. m. adjourned to meet to-morrow, Tuesday, the 16th instant, at 8 a. m.

GUN FOUNDRY BOARD,
London, England, Tuesday, October 16, 1883.

Board met at 8 a. m., pursuant to adjournment. All members present except Commodore Simpson, absent on account of sickness.
The Board proceeded to Shoeburyness and witnessed a programme of practice prepared by direction of the director of artillery and stores.
At 8 p. m. Board adjourned to meet Saturday, the 20th instant, at meridian, on board the Cunard royal mail steamer "Scythia," at Liverpool.

GUN FOUNDRY BOARD,
London, England, Thursday, October 18, 1883.

By direction of the president, sent communications. (Letter Book, pp. 204–212.)

GUN FOUNDRY BOARD,
CUNARD ROYAL MAIL STEAMER "SCYTHIA,"
Liverpool, England, Saturday, October 20, 1883.

Board met at meridian, pursuant to adjournment, and left England for the United States in accordance with orders of the Secretary of War (File Book A, p. 53) and Secretary of the Navy (File Book A, p. 45). All members present.

Adjourned to meet subject to the call of its president.

GUN FOUNDRY BOARD,
CUNARD ROYAL MAIL STEAMER "SCYTHIA,"
At Sea, Monday, October 29, 1883.

Board met at 10 a. m. at the call of its president. All members present.

After discussion, the Board decided to proceed on Tuesday, November 6, to inspect the navy-yard, New York, and the arsenals at Frankford, Pa. and Rock Island, Ill.

At meridian adjourned to meet Tuesday, November 6, at 11.15 a. m. at the navy-yard, New York.

GUN FOUNDRY BOARD,
New York, N. Y., Wednesday, October 31, 1883.

By direction of the president, sent communications. (Letter Book, pp. 214, 215.)

GUN FOUNDRY BOARD,
Navy-yard, N. Y., Tuesday, November 6, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.

Examined the navy-yard for the purpose of determining the advantages of this location for a Government foundry.

After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this navy-yard until further informed of the characteristics of other points to be visited in accordance with the president's order.

At 3 p. m. the Board adjourned to meet in Frankford, Pa., Wednesday, November 7, at 11 a. m.

GUN FOUNDRY BOARD,
Frankford Arsenal, Pennsylvania, Wednesday, November 7, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present.

Examined the arsenal here for the purpose of determining the advantage, of this location for a Government foundry. After discussion and due consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this arsenal until further informed of the characteristics of other points to be visited in accordance with the President's order.

At 2 p. m. the Board adjourned to meet at Rock Island, Ill., Saturday, November 10, at 10 a. m.

GUN FOUNDRY BOARD,
Rock Island, Ill., Saturday, November 10, 1883.

Board met at 10 a. m., pursuant to adjournment. All members present.

Visited and examined the Rock Island Arsenal for the purpose of determining the advantages of this location for a Government foundry. After discussion and due

consideration of the requirements indicated by the Board as a standard of reference, the Board reserved its decision in the case of this arsenal until further informed of the characteristics of other points to be visited, in accordance with the President's order.

At 5 p. m. the Board adjourned, to meet Tuesday, November 20, in Philadelphia, Pa., at 11 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Tuesday, November 20, 1883.

Board met at 11 a. m., pursuant to adjournment. All members present except Capt. E. O. Matthews, United States Navy (absent on account of steamer detained by fog), and Col. T. G. Baylor, United States Army (absent on account of sickness).

Filed communications. (File Book A, pp. 59–66, and File Book B, pp. 58–60.)

Sent communication. (Letter Book, p. 117.)

After discussion the Board adjourned at 4.30 p. m., to meet to-morrow, Wednesday, the 21st instant, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Wednesday, November 21, 1883.

Board met at 10 a. m., pursuant to adjournment.

All members present except Colonel Baylor, United States Army (absent on account of sickness).

The Board then proceeded to read and examine a preliminary draft of its report.

The following resolutions were adopted:

It is inexpedient for the Government to undertake the manufacture of the steel for modern cannon.

It is desirable to provide Government factory facilities on a sufficient scale to perform the work of establishing standards, of making experimental guns, and of fabricating cannon on a moderate scale, looking forward, however, to encouraging private establishments to embark upon this fabrication under the inspection of Government officers, as at present.

It is inexpedient to provide a single Government factory; two are essential—one for the Army and one for the Navy.

That on the receipt of price-lists now awaited from abroad, the steel manufacturers shall be notified, as far as practicable, of the probable cost of plant, tools, &c., necessary for the manufacture of steel for cannon, including forging and tempering, and for the fabrication of the finished gun; and that they be requested to communicate to the Board what size of contract for guns or gun material will justify them in undertaking the production either of the material alone or of the finished gun.

The Board then proceeded to consider the selection of two sites to be recommended for Government gun factories, and decided upon the Watervliet Arsenal, West Troy, N. Y., for the purposes of the Army, and the Washington Navy-Yard, D. C., for the purposes of the Navy.

Received communication. (File Book A, p. 67.)

The Board at 4 p. m. adjourned to meet subject to the call of its president.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Tuesday, January 8, 1884.

Board met at 1 p. m., pursuant to call of its president. All members present except Maj. S. S. Elder, United States Army, absent (steamer detained by ice).

Received and filed communications. (File Book A, pp. 68–76, and File Book B, pp. 61–63).

Sent communications. (Letter Book, pp. 228-231.)

The president of the Board submitted a draft of the report. Engaged revising same until 4 p. m., when adjourned to meet to-morrow, Wednesday, January 9, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Wednesday, January 9, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
After further consideration of the resolutions adopted November 21, the Board deemed it inexpedient to furnish, before the publication of its report, the information therein indicated.
Engaged revising draft of report until 4.30 p. m., when adjournment to meet to-morrow, Thursday, January 10, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Thursday, January 10, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received and filed communications. (File Book A, p. 79.)
Engaged revising draft of report until 4 p. m., when adjourned to meet to-morrow, Friday, January 11, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Friday, January 11, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received and filed communications. (File Book A, pp. 77–81, and File Book B, pp. 64, 65.)
Sent communications. (Letter Book, pp. 232–238.)
Col. T. G. Baylor, United States Army, was excused from attendance on account of serious illness in his family.
Engaged revising draft of report until 5 p. m., when adjourned to meet to-morrow, Saturday, January 12, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Saturday, January 12, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present except Col. T. G. Baylor, United States Army, absent on account of serious illness in his family.
Received and filed communications. (File Book A, pp. 82–84.)
Sent communications. (Letter Book, pp. 239–241.)
Engaged in revising draft of report until 4.30 p. m., when adjourned to meet Monday, January 14, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Monday, January 14, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Messrs. William P. Hunt, G. Paulding, and T. Davis, representing the firms of the South Boston Iron Works and the West Point Foundry Association, appeared before the Board and submitted a verbal response to the circular letter addressed them by the Board May 1, 1883. The Board requested that they would submit their proposition in writing, which they agreed to do.
Engaged revising draft of report until 4.30 p. m., when adjourned to meet to-morrow, Tuesday, January 15, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Tuesday, January 15, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received and filed communications. (File Book A, pp. 85, 86.)
Engaged revising draft of report until 4.30 p. m., when adjourned to meet to-morrow, Wednesday, January 16, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Wednesday, January 16, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received and filed communication. (File Book A, p. 87.)
Engaged revising draft of report until 4.30 p. m., when adjourned to meet to-morrow, Thursday, January 17, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Thursday, January 17, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Engaged revising draft of report until 4 p. m., when adjourned to meet to-morrow, Friday, January 18, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Friday, January 18, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Engaged revising draft of report until 4 p. m., when adjourned to meet subject to call of its president.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Saturday, January 19, 1884.

By direction of president of the Board, sent communications. (Letter Book, pp. 242, 243.)

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Thursday, January 31, 1884.

Board met at 1 p. m., at the call of its president. All members present.
Read and filed communications. (File Book A, pp. 88–91[a].)
Sent communications. (Letter Book, pp. 244 a, b.)
Engaged revising report until 4.30 p. m., when adjourned to meet to-morrow, Friday, February 1, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Friday, February 1, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received and filed communications. (File Book A, pp. 92, 93.)
Sent communication. (Letter-Book, p. 244.)
Edward Y. Townsend, president, and Powell Stackhouse, vice-president of the Cambria Iron Company, appeared before the Board to call its attention to the capacity and quality of the Cambria steel casting plant, and to ask the Board for information that would assist in preparing a reply to the Board's interrogatories of May 1, 1883. They were informed that all the information the Board had to communicate would be found embodied in its report soon to be issued, and were requested to submit in writing any statement they wished to make in relation to the Cambria works.
Engaged revising report until 4.30 p. m., when adjourned to meet to-morrow, Saturday, February 2, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Saturday, February 2, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received and filed communication. (File Book A, p. 94.)
Sent communications. (Letter Book, pp. 245, 246.)
Engaged revising report until 3 p. m., when adjourned to meet subject to the call of its president.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA, PA.,
Thursday, February 7, 1884.

Board met at 1.30 p. m., at the call of its president. All members present.
Received communications. (File Book A, p. 95.)
Engaged revising report until 4.15 p. m., when adjourned to meet to-morrow, Friday, February 8, at 10 a. m.

GUN FOUNDRY BOARD,
1727 PINE STREET, PHILADELPHIA,
Friday, February 8, 1884.

Board met at 10 a. m., pursuant to adjournment. All members present.
Received communications. (File Book A, pp. 96, 97.)
Sent communications. (Letter Book, pp. 247 a, b, c, h.)
Considered the advantages of the site owned by the Government at Harper's Ferry, Va., formerly occupied as an armory.
Engaged revising report until 2.30 p. m., when it was adopted and the Board adjourned *sine die.*

NAVY DEPARTMENT,
Washington, D. C., Saturday, February 9, 1884.

By direction of the president of the Board filed communications (File Book A, p. 98), and sent communications (Letter Book, pp. 247 d, e).

NAVY DEPARTMENT,
Washington, D. C., Tuesday, February 12, 1884.

By direction of the president of the Board filed communications (File Book A, p. 99), and sent communications (Letter Book, pp. 247 f, g).

NAVY DEPARTMENT,
Washington, D. C., Saturday, February 16, 1884.

By direction of the president of the Board sent communication (Letter Book, p. 247l), and delivered report and communications (Letter Book, pp. 261 a, b) to the honorable Secretary of the Navy for transmission to the President.

Lieutenant W. H. JAQUES,
United States Navy, Member and Secretary of the Board.